$2.00

kilobaud

The Small Computer Magazine

ISSUE # 7 July 1977

Articles

Features

The 9-inch screen of the CT-VM monitor ($175) shown here with Southwest's new CT-64 illustrates the terminal's 64-character lines, switchable control character printing, and word highlighting. At just $500 for both, these matching units provide a complete CRT terminal with full cursor control, 110-1200 Baud serial interface, and many other features.

Now $325 buys a 64-character terminal kit

Our new CT-64 terminal kit gives you scrolling, full cursor control, 128-character ASCII display (with both upper and lower case), and two 1K memory pages. It's usable with any 8-bit computer.

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The CT-64's features include:

- 64 or 32 characters per line (16 lines)
- Premium display with both upper and lower case letters, and descenders (g, j, etc.)
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Southwest Technical Products Corp.
219 W. Rhapsody, San Antonio, Texas 78216

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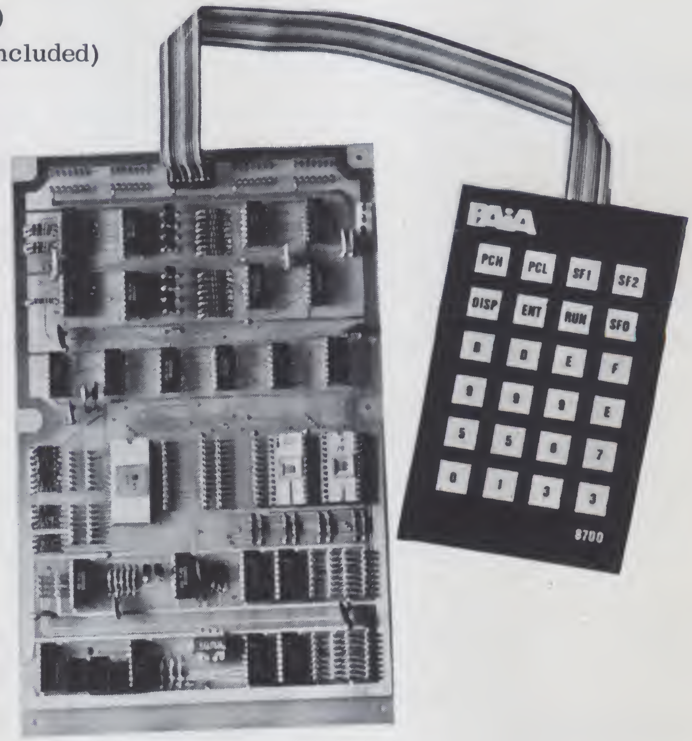

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PUBLISHER'S REMARKS

Wayne Green

Computermania

A computerfest should serve several purposes . . . it should be a place where hobbyists are able to see and try out the latest equipment – where they can meet the designers and question them directly, and where they can buy any of the latest equipment. It should also be a place where newcomers to hobby computing will be able to get an idea of what these fantastic gadgets will do – where they will be transformed from lookers to addicts.

Now, with more and more small business programs becoming available, it is time to bring in businessmen and show them what these micro-priced computers will do.

Computermania . . .an exposition at the Commonwealth Pier in Boston sponsored by *Kilobaud* and scheduled for August 25-26-27th, will try to cover the whole spectrum from advanced calculators up through microcomputers into small business computer systems. The promotion for the show will be aimed at hobbyists, at computer professionals who have been reading about micros in the trade magazines and papers and who might as well come out and take a look, at college students and at businessmen who have small business applications or industrial control uses for micros. Will we have 25,000 . . . or 50,000? Probably.

We're planning on up to 400 or so exhibitors, so if you can make it to Boston toward the last of August, you'll have a chance to see just about everything available . . . systems . . . graphics . . . boards . . . terminals . . . software. There'll be prizes and talks by major manufacturers . . . and talks by the leading brains of the field. We may even have my inspirational talk on how to get rich at hobby computing . . . a talk which should be attended by everyone.

The industry . . . manufacturers and dealers, will be getting together Friday morning for a confab. We'll be working on problems of distribution, standards, support of industry shows, etc. The people who attended the San Francisco industry meeting agreed that it was of great value. There is all too little opportunity for manufacturers and dealers to get together and help each other get things together.

The show will be running through dinner time all three days, so we've arranged . . . at great personal expense . . . to have two of the finest restaurants in the world within easy-walking distance of the show site . . . plus a couple more which rate about 3½ stars just as close. And if that isn't enough, the food concession at the Pier has agreed to add Mexican and Chinese food to the hot dogs and pizza normally on the menu . . . with extra food booths around the show. This is going to be fun.

One of the big hassles at any computerfest is trying to grab literature before it runs out. We plan to get as many manufacturers as possible to have their literature published in a giant *Computermania Guidebook* and give one of these to every computermaniac who attends. This could be 2000 or so pages . . . one never knows. One thing for sure . . . it will be an invaluable guide to just about every product being made and shown . . . and it will save you a lot of time and effort in collecting piles of literature.

I'll have more news of Computermania next month, so mark the dates on your calendar. If you are thinking of getting into the micro biz, you'd better sign up for a booth soon . . . they will be $300 until July first and $400 after that date. Write Computermania, Peterborough NH 03458 for contract forms.

This isn't a bad time of the year to plan a trip to New England . . . New Hampshire is fantastic and it is about time you paid a visit to the *Kilobaud* HQ in Peterborough . . . then on up to the White Mountains . . . the Flume, the Cannon Mountain Tramway (the first aerial tramway in North America) . . . Mount Washington . . . Lost River . . . the parade of exciting things to see is almost endless. Tourism is the major industry of New Hampshire, and once you see it you'll understand why. People drive to New Hampshire to take advantage of the low prices here on cigarettes and liquor. You might even want to move up this way . . . no income tax and no sales taxes . . . a great place for a small business.

Considering the growth at *Kilobaud,* it is highly probable that we'll still be hiring come August, so bring a resume and a statement of how you think you might fit into our weird scheme of things.

Have you got some area of expertise which might benefit others? We'll be having at least 60 hours of Computermania talk time available, so perhaps we could put you on the program. Send us a brief on your subject and some idea of your bona fides. A picture won't hurt either so we can use it in the program book. Since we will be having a whole lot of hams at the show, we're particularly interested in any ham applications for microcomputers . . . next comes applications for the systems . . . music, art, etc. Send these to Computermania Programmer John Molnar.

This is one show where it will probably take you all three days to see all of the exhibits . . . so see you August 25th at 1 pm.

Atlanta June 18-19

The computer action was so intense last year at the Atlanta Hamfest that this year the ham club and the local computer club have joined forces and are running a Hamfestival/Computerfest, with a good deal of the computer industry scheduled to be there to show and tell.

Since about 30% of the hams are getting into microcomputers, those attending last year's show found the

Seattle.

computer booths jam packed all weekend. The show has been expanded a lot this year, and there are over 120 booths; so it may be possible to actually sit down and try a micro. The systems will be there for you to check out and buy.

There will be a heavy schedule of computer oriented talks on the program . . . for instance Doc Suding will be there showing the new Digital Group ham board. He's got a fantastic talk on the new Digital Group speech synthesis system . . . and the SSTV/RTTY/CW system. Can you imagine copying Morse code and having it come out in computerized speech? And all this at hobby prices?

Even if you aren't interested in seeing all of the new microcomputer equipment and systems, Atlanta is worth a visit, what with Underground Atlanta (you'll see me there for sure), Stone Mountain Park, and Aunt Fanny's Restaurant.

I'll be on the speaking schedule too, bringing you up to date on some of the opportunities available in the microcomputer field . . . and with some words on how we managed to get *Kilobaud* started . . . a fascinating story in itself.

The Festival will be at the Downtown Marriott hotel. Call 800-228-9290 for reservations . . . or 404-971-HAMS for pre-registration info. See you the 18th.

Seattle July 30-31

On the other side of the country is another hamfest/computerfest, a swinging combination these days, when most hams are eager to get computer information and most computerists are interested in hamming as a way to interconnect their micro systems.

Those of you who miss Dr. Suding at Atlanta may have a chance to catch his

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EDITOR'S REMARKS

John Craig

Now It's History

The First West Coast Computer Faire. Absolutely incredible! I have a major complaint though. It should have been longer . . . there's no way anyone could have seen it all in 2 days! And, with over 10,000 people the first day, you were lucky if you saw anything!

Be sure and see Sheila Clarke's article in this month's issue on the Faire (lotsa pictures).

As always, there was an abundance of hardware to be seen . . . and, as usual, the software offerings were few in comparison. Just to mention a few that did catch my eye.

Art Childs (ex-editor of *SCCS Interface*) is one of several people I heard commenting on the Technical Design Labs software package. As a matter of fact, there's a good chance he'll be doing a review of same in KB in the future.

Dave Shirk of Technical Systems Consultants came over and grabbed my arm at one point and said, "Come on, and let me show you something *neat!*" They had four terminals at their booth tied into a 6800 processor which had a time-share system running. Each one of the users (booth visitors) had seven game programs to choose from, and I was quite impressed by the response time delay those users had to tolerate when running their programs. There wasn't any!

Tom Pittman (Itty Bitty Computers) was generating a stir by taking orders for his soon-to-be-released Itty-Bitty Fortran (a minimum version of ANSI Standard Fortran).

Promedics Data Corporation (Menlo Park CA) had an impressive "professional applications" system for doctors, dentists, lawyers and small businessmen (hardware and software system).

Dick Wilcox and John French of Alpha Micro Systems were showing off their AM-100 (new designation . . . previously called the CM-16). With the software package they're offering, it looks like they have what it takes to make an impact on the hobbyists and small business market. Watch them.

I thoroughly enjoyed the Faire and am not even going to try to describe everything I saw . . . it was really too much (and that's why we got Sheila to do an article on it!). Jim Warren, Bob Reiling, Gordon French and Rick Bakalinsky should all have medals pinned upon their totally wasted bodies (as a result of the ordeal) for the fantastic job they did in putting it all together.

The Kilobaud/Personal Computing Convention ("Computermania") in Boston in August will somehow be bigger and better than the Faire.

One of the most interesting experiences I've had in a long time took place on the last day of the Faire. I was invited to speak to 250 members of the Southeastern Michigan Computer Organization via a phone patch! They were having their regular monthly meeting in Detroit on Sunday evening (April 17th) and had a phone patch set up to a phone booth at the convention center. The president of the organization, Jim Rarus (with some help from Bob Whiteley), conducted the

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THE KIM FORUM

Richard Simpson
314 Second Avenue
Haddon Heights NJ 08035

Here's the beginning of a monthly feature for all you folks with KIM-1s . . . and for those of you thinking of getting one. As a matter of fact, there is a great deal of information here which will be of interest to owners of any 6502-based system. (We may just change the name to the 6502 FORUM sometime in the future.)

I would be more than happy to set aside more pages in Kilobaud *for similar monthly features on other systems. – John.*

As Manager of Product Support for MOS Technology's KIM Products for the last year, I obviously have an emotional attachment to KIM, but why should *Kilobaud* devote a forum to the products of one manufacturer? I think there are several good reasons. First, with over six thousand units sold, it is one of the most popular microcomputer systems introduced so far in this infant industry. Second, although the owner of an 8080-based system can find a constant stream of articles which relate to his system, relatively little has been offered for the many owners of 6502-based hardware. Third, during my time with MOS Technology I had the pleasure of talking with hundreds of KIM owners around the country, and this forum is an ideal way for us to stay in contact and continue the exchange of information and ideas which is at the heart of our hobby.

Where is KIM Going?

One of the questions most frequently asked me was "what are the future plans for KIM?" Most KIM owners are aware that MOS offers a KIM-2 4K RAM expansion board and a KIM-3 8K RAM expansion board. Either of these can be attached directly to a KIM-1. To expand further, a motherboard (KIM-4) must be added and MOS has planned a KIM-5 ROM expansion board, which will hold up to eight MCS6504 (2K by 8) mask-programmed ROMs (the ROMs are not provided with the KIM-5 but must be purchased separately). At present, there are two sets of software which are planned for release in ROMs – KIMath and a resident assembler/editor.

KIMath

KIMath will occupy a single ROM and consists of a set of subroutines for doing floating-point arithmetic. All calculations are done in BCD to avoid the round-off errors which are inherent in binary floating-point routines. The subroutine user can specify the precision (in decimal digits) of any calculation. The more precision specified, of course, the longer the computation time. The package will handle a maximum of sixteen decimal digits of precision plus a two digit exponent so numbers in the range of ±1 times 10E±98 can be handled. The subroutines occupy memory locations F800-FFF8 and were written so they could be used with any 650X-based system – not just KIM. The subroutines include code for addition, subtraction, multiplication, division, square roots, logs, exponents, tangents and arctangents. All the other trig functions can be generated through the use of trigonometric identities. A subroutine is also provided for evaluating user-specified polynomials, so any continuous function can be approximated.

The KIMath ROM should be available by the time you read this. If you don't want to pay $50 for the ROM, the Programming Manual for KIMath is available for $15 and it includes a complete listing of both source and object code. The manual also contains thirty-seven pages of information on using the subroutines, including a worked-out sample application. If you want to use the ROM but balk at paying $80 for the KIM-5 board to hold it, you'll be happy to know that the 6540 ROM can be attached directly to the KIM address and data busses, although you'll need a couple of extra ICs to send the right signal to the KIM-1 Decode Enable line. I'll provide an interface schematic for this in a future issue of the KIM forum.

The Resident Assembler/Editor

To create any large-scale software on a microcomputer, an assembler is a necessity. Industrial microcomputer users can use the cross-assemblers available on several commercial time-sharing systems, but the expense of going this route is too much for any but the most affluent hobbyist. Thus, the introduction of the KIM resident assembler should facilitate user software generation and make a lot more software available. The assembler and text editor are available as a set of three MCS6540 ROMs – a total of 6K of code. The $150 which MOS charges for the set may seem exorbitant until you realize that you don't have to buy 6K of RAM to store it in (which would cost as much or more) and you'll never have to load it or have it clobbered by errant statements in the program you are developing. Like KIMath, the Assembler/Editor will work on any 650X-based system. Since the program has to do terminal I/O, locations are reserved in memory page zero to contain the address of the terminal input and output routines. These locations are automatically initialized for KIM owners; users of other 6500 systems (JOLT, TIM, Apple, Baby!, OSI, etc.) can preset those locations with the addresses for the device service routines of their own system. The Editor/Assembler occupies the memory space from E000 to F7FF; thus the editor, assembler, and KIMath fit together in the top 8K of memory.

The text editor is a standard line-numbered text editor; it provides much the same editing capability you would find in a BASIC system. You can enter or insert new lines, replace old lines, resequence the line numbers, dump the text file to audio cassette or paper tape, list out lines in the file, and locate lines in the file which contain any specified text string. There is also a special command (actually, any command which begins with an X) to allow you to jump to a user-written subroutine so that you can extend the editor's capabilities to meet your own needs. Naturally, both the editor and assembler require that you have a terminal connected to the serial port on the KIM-1.

The assembler is a single-pass assembler; if your source text is on paper tape or audio cassette, you only have to feed it through once. Normally your source text will be in memory and the assembled code is always written to memory. The source code, symbol table, and object code can

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BOOKS

Interfacing Selectrics to Microcomputers
Carl Townsend
Center for the Study of the Future
4110 N.E. Alameda
Portland OR 97212
$12.00

For the hobbyist, high quality hardcopy has been a dream for some time. We now have dot matrix printers, and the Teletype has been around longer than many of us, but neither will produce camera ready copy or even good looking business letters.

The Selectric typewriter by IBM reached new highs in print quality from its beginning and the easily changeable type styles provide a real plus. Now that Selectrics are available on the used market, the problems of interfacing with the computer becomes critical.

The 49-page soft cover book *Interfacing Selectrics To Microcomputers* is a significant improvement over the author's previous *Interfacing Selectrics to the 8080* in terms of the meat offered, but for the person looking for all the answers to a simple, cheap Selectric interface, this book will be a disappointment. For the serious hardware type it will supply many answers and helpful suggestions, but plan on doing considerable work adapting the ideas to your specific Selectric.

This book reads like an engineer's design notes and observations made while building a microcomputer system around a Dura Model 1021 Selectric based terminal, an Altair 8800A, and a Lear Siegler ADM 3 video terminal. Since the author has his own system operating, he speaks as a voice of experience. He attempts to expand his concept to all other Selectric terminals, but due to device peculiarities, this goal is not really met.

The concept used by the author is to develop a computer interface that will drive the Selectric bails and function keys directly. The circuitry will probably work well for machines using 24 or 48 volt solenoids such as the Dura/Itel Model 1021, 1041, 1051, the Tycom adapter, etc. I must take exception to the comment that ". . . you should expect very little difference if it (the typer) is Itel, Dura, a 735 or another." This would make one believe that the design is well suited to the many Dura/Itel Mach 10 and MOdel 941 machines now showing up on the used market including government surplus, but wait . . . these machines use 125 V dc solenoids, so stand clear of the smoke!

It should be noted that the concept used in this book requires considerable rewiring of existing solenoids (assuming you have a terminal type device that has solenoids or you add them yourself) to bring these leads to the interface. No attempt is made to take advantage of the drive circuitry that is built into the terminal. Granted that direct drive of the solenoids is a more general solution, but it makes the interface more complex than necessary.

Another area in the design concept that I do not prefer is the use of one-shots to provide timing delays for character printing, functions, and carriage return. These delays must be made long enough to allow for the worst case mechanical variations in speed caused by temperature (cold grease), wear in the mechanism, and the need for lubrication. There is no way to account for a short carriage return or one that must travel the full page width. The net result of this type of interlock is that the machine must run at its slowest and worst case speed at all times. Again, this is a general solution to the problem but it does not use the positive, typewriter-mounted hardware interlocks that are on terminals of the class being discussed.

Now that I have noted my personal gripes with the design approach, let me point out some the fine information that the serious hardware builder will find most helpful. There is a section on selecting a machine and another on cleaning and lubrication. The section on Selectric coding is very helpful and describes exactly which bails to pull to type which letter but this will be of little use to the person working with a BCD coded machine.

There is a well-thought-out discussion about using the Selectric for input and about its pitfalls. Typical Selectric terminal timing diagram, which I suspect are Dura 1021 signals, are also helpful.

A significant part of the book gives schematics for an interface between a serial computer port and the Dura 1021 (with 24 V dc solenoids). This is an output-only device. The Center for the Study of the Future makes this interface in kit or assembled form. Prices range from $325 to $495 depending on how many parts you supply and if it is kit or assembled. Contact them for details. Please note that they are offering an interface only and you provide the Selectric and solenoids plus software. In summary, this is a very good "talk with the engineer" type of book that is well written at the reasonably experienced hardware type level. It is not tutorial in nature but with so little real information available about the Selectric interface problem, it is a ray of light in a very dark tunnel.

Ron Jenkins
Lompoc CA

Scelbi 8080 Software Gourmet Guide and Cook Book
Robert Findley
Scelbi Computer Consulting, Inc., 1976
$9.95

The *8080 Software Gourmet Guide and Cook Book* is halfway between an assembler programming text and a collection of application programs. As such, it does not replace either, but does fill a very definite need. Assembler textbooks tend to be rather light on practical examples; the programs which they contain are usually short sections designed to illustrate some point or other. On the other hand, anthologies of applications tend to be rather light on just what the program does and why; this can make it quite difficult for a beginner to make the programs run if the system for which the programs are written is different from that on which they are to be run. This particular entree from Scelbi addresses both of these problems well. The book begins with a review of the 8080 instruction set. The review is handy for either beginners or others,

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NEWS OF THE INDUSTRY

F800 Microcomputer System

Microdata Systems announces the availability of the F800 Microcomputer System complete with 8K memory and 5K BASIC.

Some of the outstanding features of the F800 system are: Ease of assembly due to its inherent modular packaging and accessibility (average assembly time 12 hours); easy interface (without additional boards) to most OEM peripherals (i.e., digital cassettes, CRT terminals, teletypes, printers, etc.); heavy duty power supply 110-125 V 50/60 Hz primary, secondaries +5 V @ 15 Amps and ±12 V @ 2 Amps with local regulation. More than enough power for a fully expanded system.

Future hardware and software available for the F800 will include 8K low power static RAM memory board, EPROM board, video interface board, 8K basic interpreter, resident assembler and editor, games and more.

Introductory price for the F800 system is $499.00 kit (includes all IC sockets) $699.00 assembled and tested. Additional 4K memory boards including sockets are $129.00 kit form and $199.00 assembled and tested.

Delivery is quoted at 30 days or less after receipt of order. Microdata Systems, 2 Mack Road, #101, Woburn MA 01801. Dealer inquiries invited.

Learn BASIC from your Computer

Why struggle through stuffy technical manuals when your computer can teach you BASIC? Computerware Software Services (CSS) is offering software on cassette which transforms your computer into an instructor on 8K ANS BASIC. Each 5K lesson, accompanied by lesson plans, will coach and prompt you through the BASIC commands and programming techniques. Part I presents the fundamental commands (PRINT, INPUT, LET, DATA, IF-THEN, FOR-NEXT). Parts II & III teach the little understood concepts of formatting (using CHR$, LEN, etc.) as well as examples of reading and writing characters to cassette via BASIC and MIKBUG. Each lesson has been professionally programmed and will run in a 12K 6800 system. Note the savings on package purchases: Part I "Understanding BASIC" $13.95; Part II "Extended BASIC" $13.95; Part III "More BASIC with MIKBUG" $13.95; Package of Parts I & II $24.95; Total package of all 3 is $32.95.

To acquaint you with the quality of CSS products, an introductory sampler package is being offered for only $6.95. This includes cassette listings and full documentation of 3 programs: 1) Lesson 1 of "Learn BASIC"; 2) an entertaining game; 3) an educational program/game.

For more information on CSS Software Products, contact: Computerware Software Services, 830 First Street, Encinitas CA 92024.

Software Design Aid for 8080 Users

Pragmatic Systems has a new software design aid to help 8080 users compute execution times for speed critical program sections. Microcomputers are commonly used in applications where program execution speeds must be accurately known. Until now much of this analysis has been done by approximation or by trial and error. This new card helps simplify this analysis.

The Pragmatic Systems 8080 Instruction Timing Reference Card presents instruction execution times and characteristics of all 8080 instructions in a concise and easy to use format. The general timing equations for the 8080 are included along with precomputed execution time columns for 8080 systems with a 2 MHz clock and memory access times from 0 to 1500 ns.

The back of the card contains instructions and equations for computing execution times of existing programs in any 8080 system. It also shows how to use the card to design program delay loops with specific execution times. Small sample programs are included as examples.

The cards, printed on heavy stock and punched for three-ring binders, are $2.00 each or three for $5.00. All orders shipped postpaid from Mt. View CA. (California residents should add 6.5% sales tax.) Volume discounts are available and dealer inquiries are invited. Pragmatic Systems, P.O. Box 43, Mt. View CA 94042.

F800 System by Microdata.

Free Microcomputer Recipe Book

A new *Microcomputer Recipe Book* covers everything from soup to nuts as far as putting together your own microcomputer operating system for personal, business, or scientific use. Under *Ingredients* there are a wide variety of system components such as computers, semiconductor and floppy disk memories, CRT displays, and hard copy printers. Suggested *menus* for complete systems range from the "Big Mac," a simple 8080-based computer hooked into the family TV set, to the "Beef Wellington" which includes a Processor Tech SOL 20 microcomputer, a dual floppy disk memory, and a DECwriter II printer as well as a video monitor. Whatever your gourmet taste demands, you will find it here . . . Bon Appetit! For additional information contact Computer Center, Inc., 321 Pacific Ave., San Francisco CA 94111.

Small Computer Catalog

A fully illustrated, 22-page color catalog describing the complete line of Processor Technology Corporation computers, computer systems, peripheral equipment and software

is now available. Applications as well as equipment are discussed. A centerfold chart reveals the computer applied in the home, for education, as a laboratory monitor and as a legal aid. Following the introduction, the catalog discusses systems, personality modules, software, memories, disk storage, interfaces and peripherals. For a copy, address Processor Technology Corporation, 6200 Hollis Street, Emeryville CA 94608.

New Breadboard System

Learn how to replace discrete devices in digital logic circuits with microprocessors and computer software. Develop new I/O interfaces and memory systems that connect directly to, yet are physically outside, the computer. Study trade-offs between hardware and software implemented circuits. Exercise comprehensive test procedures on new circuits under computer control. Set up a sophisticated classroom laboratory for logic design courses.

The Imsai Intelligent Breadboard System offers these benefits and more with its sophisticated breadboard console connected directly to an Imsai 8080 computer. The new Programmable Parallel I/O board (PIO-6) is the computer interface to the breadboard console. It brings out the computer's address lines, data lines, miscellaneous control lines and power lines to the breadboard console, as well as allowing TTL data communication between a computer program and the breadboard. Thus breadboard circuits can be built upon the bus logic of the 8080 while remaining outside the computer chassis for ease of construction and analysis.

This *new parallel I/O board* is designed for applications requiring broad flexibility in TTL interfacing of the computer peripheral devices. Extensive program control over the direction and action of the parallel I/O lines is provided through the new INTEL 8255 integrated circuit chip. Development of circuits requiring fast interaction with the computer is simplified with the extension of many bus lines from the computer to the board's edge connectors and cable.

For further information contact Imsai Manufacturing Corporation, 14860 Wicks Blvd., San Leandro CA 94577.

Intelligent Breadboard System from Imsai.

Tychon's 8080 Octal Code Card.

Octal Code Card

Tychon's 8080 Octal Code Card is a slide-rule-like aid for programming and debugging 8080 software. It contains all the mnemonics and their corresponding octal codes. The instructions are all color coded to indicate which flags are affected during execution. The pocket sized card measures 6.5 by 3 inches and it provides the instructions in a neat, logical format for quick reference.

The back side of the card is printed with an ASCII code chart for all 128 characters plus the 8080 status word and register pair codes.

Delivery of the 8080 Octal Code Card is immediate and the price is $2.95 postpaid. Quantity discounts start at ten units and custom imprinting is also available. A hexadecimal card will be available within 60 days. For further information contact C. A. Titus at Tychon, Inc., PO Box 242, Blacksburg VA 24060.

Disk Basic Etc

Binary Systems Corporation has introduced Disk Basic Etc, a disk-accessing, extended version of Basic Etc. Disk Basic Etc, an interpreter for 8080-based microcomputers, was co-developed by John Arnold and Dick Whipple of Tyler, Texas, authors of the original Tiny BASIC. Arnold and Whipple also co-developed Basic Etc, the forerunner of Disk Basic.

Disk Basic Etc is a general purpose program suitable for business and scientific applications, as well as hobbyist game programming. The sector-based DOS, which works with the iCOM floppy disk controller, makes available up to three memory buffer files to the user. The disk software includes six file manipulation commands plus SAVE, LOAD and two special integer functions helpful in keeping track of files.

Disk Basic Etc uses the lower 12 KB of memory plus 1 KB of scratchpad. User input and output routines, and stack and memory end values are specified in a user's manual. Disk Basic Etc is supplied on a certified, 5¼ inch minifloppy disk, or on a certified, 8 inch regular floppy, along with a comprehensive user's manual. The price is $50.00; the manual sells for $10.00 separately.

Disk Basic Etc may be ordered from the Micro Store, 634 S. Central Expressway, Richardson TX 75080. Orders should include a check or money order for the price of the item.

Z80-80 Piggyback Card

Now Z80 power for the Altair (S-100 Bus) without getting rid of your CPU card. Dutronics has just announced its Z80-80 piggyback card. This plug-in board enables you to use your existing Imsai, Altair, Byte CPU card and upgrade your system to a Z80. The

The Model 200 mass storage system from Micro Designs.

card design is such that all you do is pull out your 8080 and 8212 chips, plug in the board to the 8080 socket itself and the ribbon cable to the 8212.

A system monitor, on paper tape, is included with the board as well as a Z80 manual and theory of operation. Dutronics will also supply all additional software at no cost, when it becomes available, the price is $159.95 (assembled) only, *off the shelf*. For more information contact R. H. S. Marketing, 2233 El Camino Real, Palo Alto CA 94306.

Low-cost Mass Storage System

Recognizing the need for low-cost versatile mass storage for Altair-type 8080 based microcomputers, Micro Designs is offering two new digital cassette mass storage systems with up to one megabyte capacity.

An integral part of these ready-to-use systems is their complete file management software which allows the user to manipulate both symbolic and binary files with high-level commands.

The Micro Designs Model 100, a compact unit with a single cassette drive, stores one-half megabyte of data. The disk-like format of the data on the tape allows access to any single 128 byte record. The data transfer rate is 1000 bytes per second, and the tape may be searched at a rate exceeding 120 inches per second. The dual transport Model 200 puts one megabyte on line.

Both units come fully assembled and ready for immediate use. The supplied interface board plugs into the main frame motherboard connector to attach the mass storage unit to the computer. To bring up the operating system, the user loads a cassette, and transfers control to the ROM on the interface board; all further tape operations are automatic. Status lights inform the user of relevant tape conditions, and hardware error detection is provided.

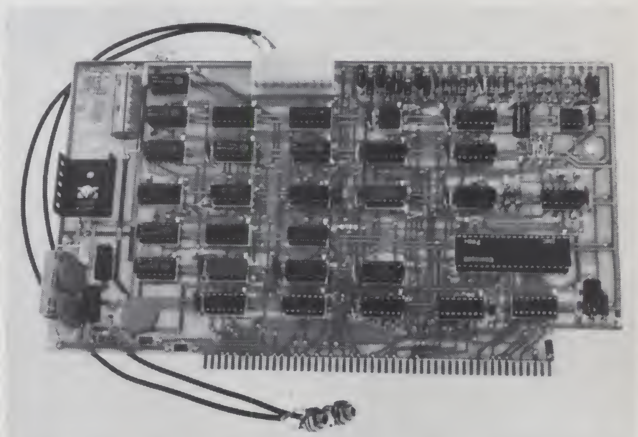
These small table top units sell for $550 (Model 100) and $825 (Model 200). Delivery is 30 days.

For further information contact Jim Zeitlin, Micro Designs Inc., 1175 Colusa Ave., Berkeley CA 94707.

VT-4800 from Video Terminal Technology.

Fond Du Lac, Wisconsin

Angelo Orlandoni and Nyles Priest have opened a microcomputer store in Fond du Lac, Wisconsin. They specialize in micros and more specifically in OSI (Ohio Scientific Instrument) products for the hobbyist, business, and education. They also handle microcomputer magazines and a variety of technical books for all levels. For information contact them at Microcomp, 785 S. Main St., Fond du Lac WI 54935.



680b-KCACR Audio Cassette Interface.

VT-4800 Video Computer Terminal

The VT-4800 Video Computer Terminal from Video Terminal Technology is the only standalone video terminal on the market today to offer the features of a professional terminal at a hobbyist price. The VT-4800 displays 48 lines of 80 characters in a 5x7 matrix. Other features include upper and lower case, direct cursor addressing, up and down scrolling, selective clearing controls, selective video inversion, and all 32 control functions decoded and available for user strapping. The VT-4800 is easy to interface to any computer with its standard RS232C I/O and selectable baud rate from 110 to 9600. With its direct cursor addressing capability and your software, the VT-4800 can perform sophisticated text editing tasks (character/line correction, insertion, or deletion). Prices start at $135 for the bare board set to $1000 for the complete assembled mode. For more information contact Video Terminal Technology, P.O. Box 60485, Sunnyvale CA 94088.

Audio Cassette Interface

The Altair 680b has received another boost to its versatility. The introduction of the 680b-KCACR Audio Cassette Interface, designed to interface the 680b bus with an audio cassette recorder/player, enables mass storage and retrieval of data. The KCACR circuitry is based on the Kansas City Standard, making data

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transfers highly reliable without any component adjustments and under widely varying conditions.

Other design features include a digital demodulator, CMOS logic allowing low power consumption, a motor control circuit for starting and stopping tape motion and the use of test points at key circuit areas. All ICs are socketed. A complete set of documentation containing diagnostic software test point waveforms, theory of operation and a detailed operator's section is also provided.

Altair 680b BASIC, Version 1.2 has been developed for use with the KCACR. Available on audio cassette, it includes the standard functions and operations of 680b BASIC in adddition to the capability of storing and loading software through the 680b KCACR. For more information write Mits, 2450 Alamo SE, Albuquerque NM 87106.

Computer with Power-On-Start

The Altair 8800b Turnkey computer incorporates the quality construction and good looks of the Altair 8800b computer in addition to such new features as power-on-start, which allows automatic program execution as soon as the power is turned on.

With the new Turnkey Module board, all the functional units of the computer – the CPU, RAM and PROM memory, sense switches and serial I/O – are contained on just one circuit board, which is supplied in the standard Turnkey version package. However, the system has the same expandability as the full front panel model 8800b computer. All hardware for the full front panel Altair 8800b computer is compatible with the Altair 8800b Turnkey model.

The Turnkey Module consists of a serial I/O channel that can operate with a variety of peripheral devices, 1K byte of RAM, provisions for 1K byte of PROM and logic for the power-on-start feature.

Available software includes a PROM-resident multipurpose bootstrap loader and a monitor PROM. Since the 8800b Turnkey system is completely software compatible with the Altair 8300b computer, it can use the full complement of Altair system software.

The front panel has a key-lock power switch which prevents accidental or unauthorized turn-on or turn-off.

The front panel also has indicators for halt, I/O transfer, interrupt request and interrupt enable; and switches to actuate the power-on-start function and to run or stop program execution.

The Altair 8800b Turnkey computer system is particularly well suited for dedicated applications but also provides simple, cost-effective general purpose computing. For more information, write Mits, 2450 Alamo SE, Albuquerque NM 87106.

Altair 8800b with power-on start.

Complete Challenger System

Challenger System from OSI.

Ohio Scientific Instruments announces its totally integrated computer system for business and professional users. Based on the time-proven Challenger 65 mainframe computer, the system provides features which include a library of powerful software and a complete line of peripherals.

The system starts with a fully assembled and tested OSI Challenger 65 with 16K of RAM, system monitor and disk bootstrap PROMs, and serial interface. It includes a Challenger Single Drive Floppy Disk based on the rugged and reliable GSI 110 Drive, plus a standalone CRT terminal and Sanyo Monitor.

The system comes complete with OSI's Disk Operating System, disk-based 6502 resident Assembler/Editor, Extended Monitor, and a BASIC program library.

The price of the complete system package including software is $2,599.00. Without CRT terminal and monitor, the price is $2,099.00.

The system can be expanded at any time to meet present or future needs. For greater data handling capacity, OSI offers dual floppy disk drives for $1,590.00, fully assembled. Thirteen OSI accessory boards can give the Challenger 65 up to 192K of RAM and 16K of I/O and ROM, D/A and A/D converters, parallel and serial I/O, cassette interfaces, video graphics display, and advanced multiprocessor capabilities.

For hard copy OSI offers a choice of two line printers by OKI Data. The CP110 dot matrix printer produces 80-character lines at 65 lines per minute for $1,500.00. The Model 22 dot matrix printer produces 132-character lines at 125 lines per minute with upper and lower case. Twelve different type font variations can be selected. The unit contains a twelve channel electronic vertical format unit to adapt to a variety of form sizes at the touch of a switch. The Model 22 is priced at $2,900.00. Both units feature adjustable width tractor feed and are fully compatible with all standard data processing forms. Ohio Scientific Instruments, Dept. KB, 11679 Hayden St., Hiran OH 44234.

8080 FORTRAN IV Compiler

Microsoft, an Albuquerque based software development firm, has announced their FORTRAN IV compiler for the 8080 microcomputer. Called FORTRAN-80, the initial release of this compiler is a full implementation of ANSI Standard Fortran with the exception of the double precision and complex data types.

FORTRAN-80 provides three data types including logical (one byte), integer (two byte), and real (four byte floating point). An

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AROUND THE INDUSTRY

John Craig

**From James D. St. John
General Manager
MicroLogic**

Congratulations are certainly in order for your efforts in establishing *Kilobaud*. Although it may be somewhat premature, since two issues can hardly be a guarantee of continuing success, I am quite sure that you have a winner. Contrary to certain published remarks I feel there is more than enough room for a new publication in the hobbyist computer field.

Since MicroLogic is a new company, I am particularly encouraged by your positive attitude toward the smaller companies serving the hobbyist market. Undoubtedly the number of companies entering the field will continue to grow in the foreseeable future. It appears that we have something of an anomaly here; normally one expects to see the industry giants pioneering the new developments, whereas the microcomputer industry is dominated by the small companies, although more and more of them will soon qualify as big companies if their previous success continues. I can't help but feel that the smaller companies have an edge in a field such as ours where new developments take place literally overnight. The larger companies appear to suffer from a substantially longer product development lead time which allows the small businesses, in many instances, to get to the market first with the right product at the right time.

For the past three years I have been serving as a consultant in the design and implementation of microprocessor-based systems and am an avid computer hobbyist myself. The bug bit me early, sometimes I think I have eaten, breathed and slept with microprocessors almost since their inception (what other field can create an expert in three or four years) and the initial excitement is still there. It was rough going just a few short years ago though, many products were marketed with sketchy or nonexistant documentation, help was hard to find, and the early purchasers often found themselves debugging the manufacturers designs. Now, having built several microcomputer kits and numerous peripherals, and having gained the knowledge essential to make them work and perform useful functions, it's easy to forget those early headaches.

But has the situation really improved? I don't think it has to any great degree. The novice computer hobbyist today is facing the same set of problems: What if it doesn't work when I plug it in? where do I go for help?, who will answer my questions? These are questions seen month after month in the letters column of every computer hobbyist publication and the responsibility lies squarely on the shoulders of the manufacturers. The prospect of making the fast buck seems to prevail with many companies; they don't hesitate to market a product without sufficient documentation, factory support, troubleshooting procedures, or quality control. There is *nothing* more frustrating than building a kit, discovering that it doesn't work, then ultimately tracing the problem to a defective component. This problem is compounded by the fact that microcomputer systems are far more difficult to troubleshoot, especially without sophisticated test equipment, than the average electronic kit.

We have all been astounded by the rapid growth of the hobby computer market, but for every computer hobbyist today how many *potential* hobbyists have given up out of sheer frustration? Sure, we're getting bigger and better every day, but the real growth potential has yet to be seen. Let's take the mystery out of the microcomputer and open up the market to the *casual* computer hobbyist, *then* we will see the microcomputer revolution.

How can MicroLogic accomplish all this? Are we introducing the ultimate everything-to-everybody universal hobbyist computer system? We certainly cannot solve this problem by ourselves; no single manufacturer can. It is going to take a concerted effort by a majority of the manufacturers which cater to the hobby computer market. I can only promise that we at MicroLogic will strive to insure that the products which we offer are backed by documentation, customer service and quality control which are second to none. A big statement from a small company? Perhaps, but we intend to limit our product line to a few items, unique items not currently available to the hobbyist, rather than try to support an entire line of equipment. Our policy is that no MicroLogic product will be advertised until it has been designed, built, and exhaustively tested. Delivery times and date of availability in production quantities will be specified, and no product will be advertised until we have firm commitments from our parts suppliers and PC manufacturer. I would like to say that we will have 500 units on the shelf before we solicit orders, but we both know that the cash flow of a small company doesn't make this feasible.

This is my plan as a manufacturer for the hobby computer market. I can offer no guarantees, unfortunately, that it will be successful. I do challenge you, John, and the readers of *Kilobaud* to report, not just on MicroLogic but on all of the companies in our field, and write us up in bold type on page one if we fail. Our industry desperately needs this type of supervision by a (hopefully) impartial judge if we are going to put an end to shoddy design, misleading advertising, and substandard customer support.

I am in the process of preparing articles which describe the theory and operation of our Power-Fair/Interrupt module and a description of the Digital Group/Phi-Deck cassette system. In my opinion this is far and away the hottest cassette system on the market (with or without our Altair interface) and it was conspicuous by its absence in the issue #2 article on cassette systems. These articles will be submitted upon completion.

Our product line to date, including products currently under development, is intended to be Altair-bus compatible. I use Altair-bus grudgingly for several reasons. First, if the Altair 8800 uses the *Altair Bus* what does the Altair 680 use? *Altair 8800* bus is getting a bit awkward, and if we really want to get technical let's call it the *Altair 8800 A/B bus*.

Seriously, my complaints with the Altair bus are not limited to the name itself. As you and others have stated, the Altair bus has become the de facto standard of our industry. As a manufacturer of interfaces for this bus I have closely studied the products of other manufacturers. There are an alarming number of cases where so-called Altair-bus-compatible (hereafter referred to as ABC) modules are not really 100% compatible. The Imsai and Altair CPUs differ on their generation and use of signals such as PRESET and POC. The newly introduced Zilog CPU boards are all culprits in one way or another as they attempt a kluge to

transform the Zilog signals into ABC versions. *None* of the Zilog boards presently available will run *all* existing ABC memories and peripherals (or software, contrary to claims). The SOL system by Processor Technology is a prime offender. They have created and defined several new bus signals and have even taken the liberty of combining the data-in and data-out buses into a single bus.

Don't get me wrong, I'm not criticizing them from an engineering standpoint. Most of these changes are either necessary to avoid overly complex hardware or are essential to overcome the limitations inherent in a bus structure which is intrinsically tied to the 8080 CPU.

I am afraid however that this trend, if it persists, will ultimately tend to undo the benefits that have been gleaned by adopting a so-called standard bus. We have to remember that the development of the Altair bus took place when there really

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Here's a photo of one of my favorite authors, Lee Wilkinson, reading one of my favorite magazines (and from the look on his face he's either reading his own article . . . or the Tri-Tek ad with Ampl' Anny!). Lee is a professional photographer who really puts his Altair system to work in helping with his business. If you haven't caught the practical small business programs he's written about in past issues let me suggest you go back and do so.

The picture was taken by a mutual friend, Pete Bickerdike, during a recent trip back to Tennessee. Pete became curious about the music stand in the back of the room and asked Lee what he used it for. Turn to page 20 and find out . . . and you'll also find the solution to one of the biggest problems we've had with *Kilobaud*.

Lee Wilkinson, Maryville, Tennessee

LETTERS

Extending Toward Self-destruction?

With respect to your column, The BASIC Forum, in the May issue of *Kilobaud:* A more appropriate question is: Should BASIC be extended at all?

BASIC (BEGINNERS All purpose Symbolic Instruction Code), was intended to be a Simple Restricted language for BEGINNERS. BASIC is one of the least consistent languages in implementation. By adding extensions to it, it will become even more so. The extensions will also destroy any usefulness BASIC had a a beginner's language. The extensions will by nature, have to be inefficient. Such things as interrupt handling should be taken care of in assembler language. Those who feel a need for extensions should roll their own through subroutings rather than cluttering up the base language with extensions that are not consistent with it.

A better plan would be to start encouraging use of assembler with macros and subrouting libraries. More efficiency, easier coding, simpler extensibility, etc., would result from this. Those who need a higher level language should move on to APL or (wash my mouth out!) PL/x (where x = I, 1, S, M, etc.). Those who are, or remain, beginners, are of course free to use BASIC, but should recognize its place in regards to other computer languages and capabilities to be used for varying needs.

I remember one letter where the writer admitted that he knew no other language other than BASIC, and then proceeded to demonstrate that BASIC was better than all of the other languages! One reason why so many people subscribe to personal computing type magazines and do not yet have systems, is that they find BASIC totally unacceptable!

The BASIC Forum would be put to better use if it were to address good programming techniques for the beginner, such as structured coding, modular design, desk checking, etc., rather than get into less fertile areas of extending BASIC.

William B. Adams
Bethesda MD

P.S. With respect to titles of articles, could we have a little more accuracy (truthfulness?). "Who's Afraid of RS 232" would have been okay but . . . "Data Communications Explained!" was a bit misleading!! It covered about 0.01% of data communications of which RS 232 is a very small part, and it only covered a small part of RS 232 itself! You had another letter in the May issue making the same comment. Do your editors feel that they need misleading titles to get people to read the articles?

Sometimes we goof, William. But not often enough to get that excited! – John.

Good Service — Well-deserved Praise

First let me thank you for your prompt response when I wrote you regarding non-receipt of my copies of KB. I now have issues 1-3 and am looking forward to each future issue.

My primary purpose in writing is to let you know about the excellent service I got from Parsec Electronics. That is the company that makes the custom enclosure for the SWTPC CT-1024 TVT and KBD-5 Keyboard. They were mentioned in *KB* issue #3 under "New Products." I wrote them asking for prices etc., and received a very prompt reply. I then ordered the enclosure kit on 16 March. Along with the order I asked a question regarding the use of these enclosures with a KBD-1 for a friend. Can you believe I received the enclosures on March 23rd along with a very nicely typewritten personal letter from Mr. Ron Wojtkowiak of Parsec? It is so nice to do mail order business with someone that gives such outstanding service as this and the product and instructions look great.

It is especially good to get GOOD service from a company since I am still involved with problems with my microprocessor kit. Off the record Wayne, could you let me know how the record of SWTPC is? In other words have you been receiving letters from readers with complaints about service received from SWTPC? You may get a real winner from me shortly. Mine may be an isolated case but I would just like to know if you have the time to let me know about that.

Gary E. Belcher
Ewa Beach HI

P.S. Wayne, if anyone writes up a contest duping program for the 6800 PLEASE PRINT IT.

Thanks, Gary. We really don't get enough letters like yours. – John.

Comments on "Making Your Investment Count"

I want to thank you for the article "Making Your Investment Count" in issue #5 by Phil Hughes. I'm totally new to the hobby computer game and am trying to decide on the proper system and setup to build. I had just about decided on the components shown in Phil Hughes' system. The only exception was the CT1024 instead of the ADM-3K ($500 is not something floating around in my wallet). The article was ideal for me since it reinforced my feelings on the best system for me.

Ed Brunelle
Alexandria VA

An Ommission

In my article on program timing loops I omitted references to *Microcomputer Programming with Modu-Learn*™, a text book on microcomputer programming I wrote for Logical Services Inc., the *Intel Microcomputer Applications Handbook,* and Adam Osborne's *8080 Programming for Logic Design.* These books all contain additional information on program timing which might be of interest to your readers.

Tim Barry
Mountain View CA

Please advise if this ommission is to be counted as a mistake, Tim. We're keeping track. – John.

Learning by Modifying

The program "Lunar Lander," as appearing in your May issue, has a major error, probably a typo. Line 520 should be

520 IF V = 0 GO TO 585

The original line allowed wins with high velocity impacts.

A suggested modification, renumbering line 510 as 525 will allow checking for a perfect landing on empty fuel tanks.

Do continue to publish short game programs such as this. I have already spent an hour or so modifying the original to provide a better formatted output, to print the impact velocity on crashes, and when out of fuel to continue the calculations to find the impact velocity. Playing around with an existing program is one way to get started in programming. You have something that already

works so that small additions or deletions can be quickly evaluated and debugged instead of trying an entire new program at once. I have gotten my feet wet on assembly language by modifying existing game programs. Perhaps you could run an article in *Kilobaud* along these lines.

Charles Kaza
Flint MI

Perhaps you should write it, Charles. – John.

Submarine Seed

I would like to congratulate you on a fine magazine. I have been a reader of another hobby magazine for almost a year and thought I was satisfied with just one – until I picked up a copy of *Kilobaud* at the local computer store. You will find with this letter a check for my subscription.

I would like to suggest a modification to the SR-52 program "Submarine" in Feb-77 *Kilobaud*. A good way to initialize the seed for a random number generator is to have the computer count until the user stops it, then use the count as the starting seed. This way the sequence of numbers is unpredictable as well as psuedo-random. The best way I have found to do this on an SR-52 is with the following:

Address	Instruction
000	SUM rr
003	"73"
004	LBL E
006	1
007	"73"

Where rr is the register where the seed is to be put and "73" is op code 73 (see the *SR-52 Programming Workbook*, p. 90). Using "73" will speed up the loop but if it needs to be placed in some other part of memory a GTO can be used. To use this program press E then wait a few seconds and press HLT. Since Submarine uses seeds between 0 and 1 you should take the sine of the number and then square the result to get the initial seed. Also I would recommend using register 98 or 99 for the seed since they are only cleared when the calculator is turned on.

Scott E. Lee
Little Rock AR

Classified Section in Kilobaud?

Congratulations on a fine magazine . . . I find something new in it everytime I pick it up. One thing though, would it be possible for you to have a "classified" section? Not for companies, but just for people who have computer stuff to sell or swap? My dilemma is that I want to sell my printer, one of those Friden jobs by Burroughs (TM20K714 and 15) – you know the one that Herback & Rademann sold. And I even have schematics, which are scarce as hen's teeth, and I don't know where to advertise. Could you please help me? By the way, I am selling copies of those schematics for $6.00 each – to cover copying and first class shipping. Maybe you could put a plug in for those, as I have heard that there is no documentation available for those units. Well, enough of my ramblings, maybe sometime I'll write up something using that MC14433 in a remote data handling situation for a 6800 system. Maybe you could tell me if it would be worth doing. Thanks again!

Tim Ahrens
Austin TX

Well, Tim, we tossed the idea around and decided against having a classified section in KB. I would strongly recommend ON-LINE ("A Buy & Sell Forum for the Computer Hobbyist" . . . as described by the publisher, Dave Beetle). They're reasonable, have wide distribution and I like it. The address is: 24695 Santa Cruz Hwy, Los Gatos CA 95030. – John.

Dick Wilcox, Where Are You?

I have received my three issues of *Kilobaud* and to say that I find this magazine the best and most useful one that I have ever read would be putting it mildly. One nice feature that I particularly like is your comments on each article. You give a good overview and set the tone of the article (or put it into context) and I like that. Keep up the good work.

There are two types of articles which I am following with particular interest. One being the Z-80, or new CPU chips and the other on software standards. My interest in new CPUs comes from the systems designer deep inside somewhere. He keeps saying what a great system I would have if I had two microprocessors, one CPU to handle the I/O, system monitor and overhead, and the other to crunch numbers (or run programs). So my interest is peaked with talk of new more powerful microprocessors. Then I get excited about all of this and go to my hideaway to work with my homebrew 8080 and find that all I can do is watch the lights blink as I flip the switches. This awakening to reality brings me to my next subject of interest, software. I look over the ads to see what is available and find that there is nothing there. My problem is that my system isn't canned (at least the software and micro computer systems companies would like for me to think it is my problem). So I give in and buy a program and attempt to use it only to find that the complete documentation they were talking about told me where to flip switches and the program's requirements. – So I plow ahead to change all their I/O statements for that teletype device so it will work on my homebrew SWTP Keyboard and Radio Electronics TVT I. (The TVT I has been modified to be under complete software control). I no sooner get started with this when I realize this "neat", "Super" 4K program is spread all over 65K! &*%#@*%! As I yell obsenities at this computer generated junk program I go over to my corner and pick up *Kilobaud* to try to calm down and keep from destroying something. I open up the magazine and I run across an article by Dick Wilcox "The Hobbyist's Operating System." To find out that the man is talking of standardizing software for that micro-beast in the other room was like a breath of fresh air or more like the cavalry coming over the hill to the rescue.

I read both January and February issues and when I received the March issue and discovered that you left him out I was a little miffed at you. I hope to find his articles in the next issue of *Kilobaud*, and the next, and the next . . . Keep all articles like that coming; they are of keen interest to more than just me. Maybe he and John Molnar's "Practical Microcomputer Programming" (Jan and Feb) could get together on their proposed standards. I also believe you could do your readers a great service by acting as a standards clearing house for microprocessor software.

If you haven't guessed by now I plan to develop an OS using Dick's guidelines, so put me on the list of those involved in this project. Keep up the good work.

Jack C. Ellis
Andrews AFB MD

I Like It!

I would like to take exception to Dave Winthrop's review of Charles Sippl's *Microcomputer Dictionary and Guide.* Dave Winthrop has every right to dislike things: without people like him we'd all be stuck with the Altair Bus. But on the other hand, I think he failed to recognize the good points of the book. Possibly, by answering some of his allegations from my point of view I can show why I wouldn't dream of parting with my copy of Sippl's book until something better comes along.

Statement: "Not only does it omit and inadequately define terms that are clearly common to microcomputer usage, it is absolutely stuffed with terms that have absolutely nothing to do with micro-

computers." *Reply:* As a graduate ME who learned about computers from an old IBM 1130 and the now somewhat old 360/95, I wholly subscribe to publisher Wayne Green's philosophy that many of us are beginners at hardware, and many of us wish to "play the violin, without knowing how to build one." While I cannot argue with omissions from the book, I do appreciate the added entries as essential background info; not being a EE handicaps some of us, and the applications data, i.e., Intelsat IV-A, etc., is nice to know. "Inadequate definitions" is erroneous. I particularly appreciate *KB*'s Glossary section each month, but I find myself referring to Sippl's constantly for additional definition. I might add, I have yet to find a term in *KB*'s Glossary that was not covered by Sippl's.

Statement: "For example there are 23 definitions which pertain to the term phase. . ." *Reply:* Same comment as above, those of us who are not EE-types continue to find these terms sprinkled indiscriminately through almost all computer journals and we need some respite. I would hate to see basic EE terminology go the way of the computer priesthood.

Statement: "definitions . . . drawn . . . from specific products . . ." *Reply:* Since different companies and individuals like to invent new terms for existing entities, I think it only fair that someone has tried to collate them for us. I do not consider them to be superfluous, but a very real problem to all hobbyists.

Statement: "30 definitions of the register". *Reply:* Again, as in the last reply, the number of definitions necessary are equivalent to the number of different ways different corporations and individuals use the term. It would be far more reasonable to blame the individuals responsible than the individual who is trying (possibly hopelessly), to bring all these similar terms together. I submit that any problem of similar definitions within Sippl's book lies primarily with the industry and not with its servant.

Statement: "dictionary is virtually without illustration". *Reply:* In my opinion this is the only responsible and credible facet of the critique. I couldn't agree more.

Statement: "This dictionary was probably rushed to market . . . a book one quarter the size could easily convey 99.5% of all the useful information. . ." *Reply:* This may possibly be true, but I doubt it. I only know that I have something real in my hands as opposed to idle boasts. If Dave Winthrop ever decides to fulfill his claims, I'd like to be the first to critique it. I tire far too easily when presented with people who talk about a better "world" for us all, when the same person is too lazy, or possibly incapable, of producing the changes he purports. When Dave Winthrop produces, I'll listen, otherwise, he's just another Howard Cossell, all talk and no action.

Yes, I'll keep my "dictionary" thank-you. It has faults to be sure, but I'd hate to think that some other hacker like myself might be turned away from the true benefits of this book. Like everything else in the world of computer hobbyists, we do with what we have until something better comes along. To date, Sippl's, to my way of thinking, is the only and therefore the best source available to us.

In summary, I hope Dave Winthrop realizes that everyone has a purpose in life, even if it is to set a bad example; and more importantly, having been to Vandenburg AFB in the last month on business, I'm glad somebody in Santa Maria is doing all they can to offset that terribly cold wind that comes off the ocean.

Steven J. Perenic
Titusville FL

Hot and Heavy Duty?

I believe that your readers should be aware of two potential pitfalls with the "Heavy Duty Power Supply," pages 78-80 of issue number 4, which just arrived. I have not built the supply myself, so my comments are intended to be shrewd guesses about what is likely to happen.

1. Don't be surprised if the 5 V regulators on your plug-in boards get unusually hot. This will be especially the case if your system draws little current on the 8 V line. For instance, if it draws only 1 A, then the actual voltage on this line will be nearly 12 V, and your regulators will get pretty darn hot. With proper heat sinking they will survive, but you will have unnecessary heat on your boards. What can you do about it? Either add several diodes in series with the 8 V line to drop the voltage or reduce the value of the filter capacitor to about 2,000 mfd. The second fix will reduce the average voltage to 10 V while increasing the ripple component. Both of these fixes will have to be adjusted as you draw more current.

2. Don't be surprised if your zener diode regulators on the ±16 V lines get overloaded and possibly fail. On the original Altair CPU card this would, in turn, lead to a zapped 8080 chip. It may happen, because the actual voltages on these lines can easily go as high as 23 V. This, again, is likely to happen when little current is being drawn. If all your boards use 3-terminal regulators on these lines, you should have nothing to worry about. Some boards use zener diode regulators, and these could then be overstressed. Measure the actual voltages on these lines, and if they are above 19 V, then I suggest precautionary measures. You can add either diodes in series with these lines or a properly chosen series resistor or – most elegant of all – you can replace the entire zener regulator with a 3-terminal regulator.

With these precautions and counter-measures in mind, this supply should serve its purpose. The specified parts are conservatively rated. I would, however, not recommend that several of these supplies be ganged to achieve higher current ratings. There are better ways to go.

Vector Graphic, for example, sells a kit of parts for $60, which will supply 18 A on the 8 V line and 2.5 A on the other lines. If you need more, Imsai has a 28 A kit for $100. Or, if you are a member of SCCS, you can get a 20 A transformer alone for $28. Each of these is high quality and well regulated.

Rudy Hirschmann
Pacific Palisades CA

P.S. Congratulations on a fine entry into the computer publications field. Also many thanks for you pioneering work on Micro-8. To show my appreciation, I have become a life subscriber.

The New Kilobaud Glossary

After reading several years worth of *73* and *Byte* magazines I noticed the upsurge of microprocessor articles and attendant interest. It seems that there is a lot of confusion as to what the author is referring to when using computer terms and acronyms since these have grown as rapidly as the computer technology itself. Since I am a professional programmer for one of the largest firms in the world, these terms are a part of my every day language. My boss, a noncomputer type manager has difficulty getting intelligence from correspondence containing computer acronyms and terms and requested that I devise a glossary for easy decoding in the office. With this in mind I devised the following list to aid the beginner or the ham with only a casual interest in computer terminology. The list though not complete covers some of the terms found in the leading electronic and microprocessor journals. For those of you do-it-yourselfers I would recommend reading up on chemistry, Latin, Semantics

and obtain a good dictionary before tackling the job. As you will notice, the list reflects common sense and lots of research.

Memory Dump. A place where burned out programmers go.

UART. Modern version of "Thou Art." (Biblical)

FIFO. Name for a dog.

LIFO. Slang for prison inmate with a life sentence.

BAUDOT. (Bridgette) Sexy French actress of the '60s.

Serial. Breakfast food.

Hard Copy. Pornographic reading material.

Subroutine. Chores performed by submarines.

MODEM. (Latin.) TV police term; i.e., Modem Operandi.

Hardware. Local plumbing store.

Software. Gloves, shirts without starch, etc.

Firmware. Brassieres, girdles.

Skinware. Pantyhose.

Byte. A mouthful; a magazine.

Bit. Less than a byte.

Diagnostic. A routine performed twice daily by one who doesn't believe in a supreme being.

BASIC. Sixteen weeks of training in the military .

Fortran. Third planet from Antares.

Register. Grilled device found in floors or walls, usually covered by children or pets.

LED. Used in circuit boards. Chemical symbol Pb. Atomic wt. 206.

ASCII. (AS-KEE) A participant in a question/answer session. The asker and the askee. The director of the question is the asker; the one expected to answer is the askee.

Interface. What we are *really* thinking.

PROM. Acronym for high school dance. (Junior or Senior.)

Erasable Prom. Date of above not sure, subject to change.

RAM. Male sheep, L.A. football player.

Bus. Large passenger vehicle.

I/O. Declaration of debt; I.O.U.; I.O. Sears, etc.

Mnemonic. One who suffers from chronic mnemonia; a respiratory affliction.

Matrix. A woman in charge of a girls dormitory.

CPU. Much like a certified public accountant but different in some respects.

Floppy Disc. A rock group from LaBrea CA.

Backplane. Rack for hiking gear.

Bubble Memory. Pertains to my XYL's cerebral retention.

Analog. Science fiction paperback.

Digital. Having to do with the fingers and toes.

My data systems workers agree that the list should be a help to the neophyte and the expert alike. Our computer uses eighteen bit addresses and thirty bit words and tracks airplanes among other things that may be of interest to the technical minded.

When my boss read the list he mumbled something about sending me a memory dump – or was it that he was sending me to the memory dump? Well, let's see now – Memory Dump. That was number one on my list.

Eugene F. Ruperto
West Alexander PA

Great! Be sure and include "nybble" in your next update, Buck. You could have fun with that one! – John.

Organizing An Explanation

I enjoy the magazine. My special interests may seem a bit unusual right now, but I think you'll see a lot more like me as the computer hobby (hobby?) grows, so I'll pass them along.

1. Tell Wayne Green not to apologize for the ads. When I get a new magazine I look first for any articles about my kind of computer, and read them. Then I read all the ads. All. Sure, I've seen most of them before, but they change from time to time, and my own views of what I want next change from week to week. I'm actively looking for some items, and I want to know the latest on what's available, where, what it will do, what it costs, etc.

2. I want to learn programming, but I'm sorry to say that generalized information on programming is very hard to follow, specialized material on programming other kinds of computers seems largely a waste of time for me, and most of the material available even for my own computer would be very easy to follow – *if* you already understood what the explainer (unquote) is trying to say! Very few people who understand programming are able to organize an explanation in such a way that a novice can follow it.

3. Most of the articles I have seen on programming are too wordy. They preach or lecture. Let us have specifics. For example, I'd give a lot for a few articles about programs for my computer which would explain step by step exactly what is being done. I have programs that work, but when I try to see how, I run into dead ends. The writer of an article like this needs to have a novice like me at his elbow – or else a tape recorder constantly saying "Why? How?"

4. My computer isn't a one-man horse. A couple of my children (who are grown) and six or seven grandchildren (who aren't) are learning to use it along with me, and I expect that one or two of the grandchildren, who are in computer clubs at school, are going to get far ahead of me.

5. I intend to do some useful work with my computer, in addition to playing some games. I decided to get a low-priced one to learn with (not then knowing what I know now) and chose the KIM-1 because it was the cheapest one I could find that had provisions for input and output and a respectable memory. I intended to give it to one of the kids and get a more expensive one later. Surprise! KIM-1 is a remarkably powerful outfit, probably able to do anything I'll want it to. I'll add more memory, a keyboard input of some kind, a paper output device of some kind, and maybe later a CRT.

6. So I read the ads, and I see that nearly everything is compatible with 8080, 6800, etc. Rarely does an advertiser say anything about the 6502. Why don't advertisers either explain in more detail, or list more of the popular systems their equipment is compatible with, or at least offer to answer questions about using it with other systems. I skim over ads that mention only other I/Cs, but I stop and read every comma if the ad says something about the 6502.

7. I was not a club member until I got the KIM. Within three weeks afterward, I was not only in a club but was on a first-name, drop-over-after-dinner basis with two other KIM users who live within 10 miles of me; I have the names and addresses of 10 others who live within 50 miles, and of 23 others within two hours or so by car. I've met six or seven of them. I don't disagree with Mr. Green's estimate of the distribution of hobby systems; there are probably many more Altairs and Imsais and SWTPs in the area than KIMs. But unless this area is exceptionally rich in KIMs, his figures on the total numbers seem low.

8. I'm interested not only in buying hardware, but also in buying some programs. Specifically, I want to use KIM for information retrieval (file reference?) and for help in typing (word processing?). And there are others, even some more games that I intend to buy.

9. It's clear that what I need is a short college course in programming KIM. If I can find one I'll take it. In the meantime, I keep reading magazines and books. I learn a little – just a little – from each, and maybe some day I'll make it.

10. One final note occurs to me: to mention the books that came with the

KIM. There are three of them, and they are magnificent. Problem is that they were written for people who already under-

continued on page 86

NEWS
OF THE INDUSTRY

from page 10

extended version of FORTRAN-80 with double precision and complex data types is forthcoming.

The compiler generates pure, relocatable code (may be placed in ROM), and the runtime package may also be placed in ROM. The one-pass compiler requires less than 12K bytes of memory, and the runtime system less than 6K bytes.

A relocating linking loader is included with the FORTRAN package. Therefore, subprograms may be compiled separately and linked at load time. This also means that only the specific subprograms required are loaded (including system subprograms).

Another part of the package is a relocating assembler and an assembly language debugging program. The assembler may be used to produce FORTRAN compatible subprograms. The debugging system may be used with the load map produced by the loader to debug FORTRAN and/or assembly language programs.

Additional features of Microsoft FORTRAN-80 include multi-statement code optimization, mixed-mode expressions and all standard FORTRAN library functions for reals and integers. Individual copies of FORTRAN-80 may be purchased for $50 including documentation. The manual is $15.

For further information contact Microsoft, 819 Two Park Central Tower, Albuquerque NM 87108.

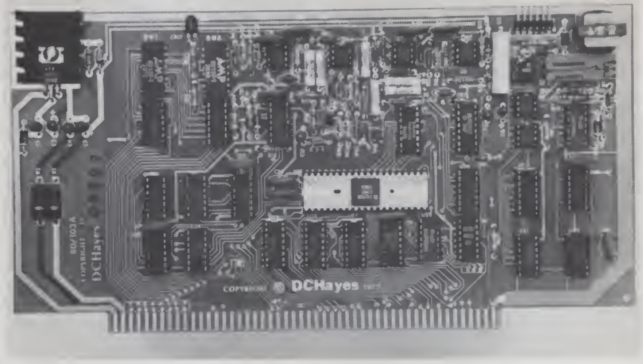
80-103A Data Communications Adapter

Data Communications Adapter (DCA), is an Altair compatible asynchronous serial interface incorporating a fully programmable frequency shift keyed (FSK) modem.

Programmable features include auto dial and answer, originate answer mode, data rate 110-300 BPS, echo suppress tone generator, error detection and self test for complete internal verification. Other features are fully buffered bus, outputs drive over 25 Altair bus loads; complete digital modulation and demodulation with precision filter – requires no adjustments or fine tuning; option for interrupts on ringing, transmit register empty, receive register full; switch selectable address. The double sided PC board with plated holes, gold plated card edge connector, solder mask both sides, and silk screened component designation is available as an assembled unit or as a bare board.

Special introductory price for orders received before June 1, 1977, $247.50; regular retail price, $279.95; bare board with manual, $49.95; manual only, $7.50.

Shipments are 4 to 8 weeks from receipt of order. No kit production is planned at this time. Further information available on request from D. C. Hayes, P.O. Box 9884, Atlanta GA 30319.



D. C. Hayes 80-103A DCA.

ALT-256**2 Graphics System

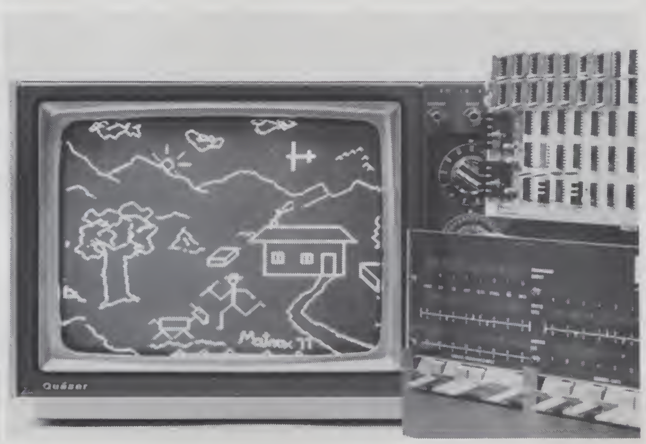
The ALT-256**2 is a 256 x 256 high resolution graphics device designed to plug directly into Altair, Imsai or similar computers. The card contains all interface electronics, a TV sync generator and its own 65,536 x 1 bit refresh memory. It plugs directly into one slot of any Altair bus compatible computer. The built-in refresh memory allows much greater flexibility and speed since no CPU time is required to refresh the screen.

The output is a composite video signal which can be connected to any TV monitor or the video portion of a TV set. Both American and European standard versions are available. The unit produces a high resolution 256 x 256 dot raster.

The ALT-256**2 board occupies a single Altair bus slot and requires 4 output ports and 1 input port (port addresses can be positioned on any 4 location boundary via on board jumpers). Two output ports are used for storing the X and Y coordinates of the addressed dot. Another output port turns the addressed dot on or off. A fourth port is used to clear or preset the entire screen.

Multiple ALT-256**2 cards may be combined to form graphic systems with grey scale or color capability. The ALT-256**2 can also be synchronized to an external sync generator chip for use in systems where video mixing is required.

The unit is priced at $395 and is available from Matrox Electronic Systems, PO Box 56 Ahuntsic Sta., Montreal, Quebec H3L 3N5.



Matrox Graphics Device.

Co-Resident 8080 Editor/Assembler

Tychon, Incorporated announces its co-resident editor/assembler (TEA) for 8080 systems. Requiring only 5K of memory (R/W or PROM) it is completely I/O independent relying upon its own I/O software

or the I/O routines already available in a user's system. The Tychon Editor/Assembler accepts both octal and hexadecimal values throughout the program and the program listings may be in either octal or hexadecimal form. The switch between octal and hex is made at any time using keyboard commands. The TEA package is the only editor/assembler available which allows the user to easily change the numbering system used. The editor/assembler is relocatable using a special relocator within the program which will place TEA anywhere in the 8080's memory space. The program is available in 1702A or 2708 PROMs and on paper tape. Listings are also available. Delivery is immediate. Prices start at $35 for a paper tape version plus the User's Manual. For further information contact Tychon, Inc., Blacksburg VA 24060.

Low-Cost Microcomputer Software

Digital Research now offers CP/M, a low-cost advanced disk operating system designed for use with IBM-compatible diskette-based computer systems which employ the Intel 8080 microcomputer. Previously available only to OEMs, CP/M has been in existence for over three years in various manufacturers' products and has undergone extensive field testing. The functions of this software package include named dynamic files, program editing, assembly, debugging, batch processing, and instantaneous program loading, resulting in facilities similar to popular timesharing services. CP/M is an "unbundled" software package which can be easily adapted to any 8080 or Z-80 computer system with at least 16K of main memory and one or two IBM-compatible disk drives. Although the standard CP/M system operates on an Intel MDS, the field-modification manual provided with CP/M tells how to alter CP/M for other hardware configurations. Price for a complete CP/M system in object form with documentation is $70, documentation (set of 6 manuals) alone is $25. For further information, contact Digital Research, PO Box 579, Pacific Grove CA 93950.

6502 Resident Assembler, Tiny BASIC Interpretive Programs on ROM

Microcomputer Associates Inc. announce their 6502 Resident Assembler Program (RAP) and Tiny BASIC interpretive program on ROM chips. Two 2K x 8 ROMs comprise the software ROM package housing the 1.75K Resident Assembler and the 2.2K Tiny BASIC program.

Formerly contained in seven 1702A PROMs, RAP is the only single pass Resident 6502 assembler available today. Statements are entered either from paper tape or directly from a terminal keyboard. RAP generates a listing and places object code into RAM for immediate execution. A minimum of 4K x 8 RAM memory is needed with the users' 6502 microcomputer. RAP allows a 6502 microcomputer to function economically as a microcomputer development system. Following assembly the programs can be debugged using the debugging facilities of DEMON, Microcomputer Associates' DE-bug MONitor program housed in the 1K ROM section of a 6530 ROM/RAM-I/O-Interval timer circuit. A text editor is included.

The ROMs are totally pin-compatible with 2708-type PROMs.

The RAP/Tiny BASIC ROM package (SW101) is priced at $200 and includes full documentation with deliveries from stock to 30 days ARO.

RAP is also available on a set of seven 1702A PROMs (SW200) for $295. Tiny BASIC is available either in paper tape format (SW300) for $25 or on a set of nine 1702A PROMs (SW201) for $275. All software is fully documented with deliveries from stock to 30 days ARO.

For further information contact Darrell Crow, Microcomputer Associates, 2589 Scott Blvd., Santa Clara CA 95050.

PUBLISHER'S REMARKS

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fantastic act at Seattle. There will be a whole series of microprocessor talks . . . introduction to digital logic . . . introduction to computers . . . to programming . . . how to get started . . . and a forum on the future of the computer hobby. Will you have time to see the exhibits? There are even rumors that I may be talking too . . . in case any of you are interested in how to make money in this new field. Big money. Other than by publishing magazines . . . that is . . . that's already taken.

This will be the first opportunity for the microcomputer industry to show in the Northwest, so they will probably be there in force. It isn't all that far from Silicon Gulch for most of them.

The computerfest will be held at the Seattle Center, with some of the other formalities taking place at the Washington Plaza Hotel.

EDITOR'S REMARKS

from page 3

meeting over the phone!

If you ever get a chance to talk to 250 people from inside a phone booth . . , be sure and try it.

Miscellaneous

Jim Brown needs help! His article in the March issue of KB ("Using the '$50' Terminal") has generated an unprecedented response from readers. He can't supply 8080 or 6800 listings for his software because it was written for his home brew 16-bit machine. If anyone who has taken his flowcharts and generated the 8080 or 6800 code would please sit down and write it up as an article for *Kilobaud* he would be very grateful. Sounds like a good idea.

THE KIM FORUM

from page 4

be located anywhere in memory you wish. You may have several different source files in memory simultaneously. If you have insufficient memory space to store a large source program, you can break it into several segments, store each segment on audio tape, then bring back one segment at a time for assembly. The assembler will assemble the successive segments until it encounters an "END" statement. It will then put out the symbol table and terminate assembly.

Although the editor is fairly limited (it has no capability to edit within a given line, for instance) it is quite sufficient for editing assembly language programs. The assembler is very fast and with good error diagnostics. Perhaps its only serious fault is that the printed symbol table is not sorted alphabetically and no cross-references are given.

Other Hardware is Available

When I left MOS Technology they had just pro-

duced the first samples of a new 4K static RAM. It would be reasonable to guess that they will incorporate it into the KIM line later this year, perhaps as a 16K (byte) RAM board.

I have heard rumors that other companies are planning to offer EROM boards, A/D converters, and video display modules compatible with the KIM motherboard bus structure. I saw a flyer the other day for a motherboard for KIM which would accept Altair bus boards. STM Systems is developing a floppy disk package for their BABY! which should be transferrable to KIM. If you hear of KIM-compatible units, drop me a line and I'll mention them in future editions of the forum. In the next issue I'll cover some of the software available for KIM.

The User Group

As a final note, every KIM owner should subscribe to the KIM User Group Newletter. This publication (which is not connected with MOS Technology) is issued every 4-6 weeks and is filled with programs and useful information. A recent issue contained a program to allow KIM to read and write cassettes at six times the standard speed with no hardware modifications. Send five dollars for six issues (and ask that your subscription start with the back issues) to: Eric Rehnke, 425 Meadow Lane, Seven Hills, OH 44131.

I would enjoy hearing from you too.

BOOKS

from page 5

in that Scelbi's mnemonics are different from those used by Intel. This is due to a desire to make the 8080 mnemonics upward compatible with those for the 8008; not a bad idea but rather confusing to those of us who learned the 8080 first. Fortunately there is a conversion table in the back, so you can look up any confusing symbols which occur in the text (suggestion – the cross reference table is ordered by function; an additional alphabetical table would help in future editions). After introducing the instruction set, the book discusses the stack, and then the cookbook section.

The chapters, in order, are General Purpose Routines, Conversion Routines, Decimal Arithmetic Routines, Floating Point Routines, I/O Processing, and Search and Sort Routines. Each chapter addresses a number of common problems, presenting flowcharts and well annotated assembler listings to illustrate possible solutions. The routines are written so that they can be combined easily, and are explained well enough in the text that even a beginning programmer should be able to see how they work without difficulty. Some high points are the monitor routines in the first chapter, the ASCII/BAUDOT conversion routines, and the floating point routines. The latter are integrated, and an octal memory dump is given in the appendix. One of the things I appreciated most is the extensive set of appendices; too many books fail to provide the tables needed to make conversions. The book is well worth its price.

John A. Lehman
Ann Arbor MI

Scientific and Engineering Problem-Solving With the Computer
William Ralph Bennett Jr.
Prentice-Hall Inc 1976
457 pages, $17.95

If this ponderously titled book were called something like *Not-So-Basic BASIC* and was on the shelves of your local hobby computer pusher, it would be a best seller. But it's not and it isn't, so you'll have to look in your local college bookstore or order it specifically.

Two chapters alone are worth the price of this book: chapter 3 "Plotting and Graphic Display" and chapter 4, "Language." Chapter 3 discusses the routines needed for getting different plots out of printers and CRTs but the main emphasis is on the lowly Teletype. Subroutine or program segments are included for plotting two or more simultaneous functions, contour plots, plots with hidden lines, and stereoscopic projections. For the non-scientific oriented computer hacker the 96 page chapter on language is the high point of the book. Bennett begins an excellent discussion of the structure of language by means of the "monkey-typewriter" notion: If enough monkeys were allowed to pound away at typewriters long enough, all the collected literature of mankind, past, present, and future would result. By using letter frequencies and letter-pair frequencies of different language samples from different authors and a randomizing BASIC "monkey program," Bennett produces gibberish which can be easily identified as coming from German, French, Italian, Hemingway-English, or Poe-English monkeys. The main thrust of this chapter is the analysis and solution of simple cryptograms and ancient writings.

The book is actually a text for Bennett's course at Yale: "The Computer as a Research Tool" which has made the Yale students' top-ten list several times. As such, this book assumes no prior knowledge of computers but it doesn't talk down to the reader. Make no mistake, the author makes some demands on your intellect but his style is easy to understand and he has a sense of humor which shows. Some of the mathematics may be too much for some readers but these sections can be easily skipped. The introduction gives a complete background for BASIC. Where dialects of BASIC differ the author will warn you. All the programs in this book were run on a Hewlett-Packard minicomputer and used no more than 16K of memory. Chapter 2, "More Advanced Programming," contains concepts from introductory calculus (derivitives, Taylor series, definite integrals and matrix algebra). Applications programmed in this chapter range from economic input-output analysis, pattern recognition, to solution of simultaneous equations.

Chapters 5, Dynamics, chapter 7, Wave Motion and Fourier Series, and chapter 8, Electronics and communications are for the

Here it is . . . the answer to the small type in Kilobaud! *I expect that music stands will become the next really hot item to be carried in computer stores across the country! We gave you the problem and now we've given you the solution. No more complaints, okay? – John.*

physics freak and are the most difficult in the book. Chapter 7 does contain a good analysis of the "Watergate problem" – detecting the doctoring of audio tapes. Chapter 6, Random Processes covers the programming aspects of simulations. Among the most interesting are those simulations of the spread of disease epidemics with examples of the common cold, the "Martian problem" of a fatal disease with no cure, and syphilis.

This book will go a long way to help you fill that software gap that you acquired now that you've got your 8K BASIC (with string and matrix variables) up and running. Of the score or so books on BASIC I've seen, this is by far the most complete and useful.

Ronald N. Orr
Redondo Beach CA

AROUND THE INDUSTRY

from page 13

was no precedent and no inkling of its future. The rapid increase in the level of sophistication has brought us to the point where the limitations of this bus structure are becoming more and more apparent, yet it is still adhered to (more or less) because it is *the* standard.

I propose, therefore, that we at least consider the creation of a new, processor-independent, standard system bus. In order for such a venture to succeed it would have to be supported by several companies, and that would require a lot of cooperation and stimulus – perhaps from *Kilobaud*.

A forum of manufacturers similar to that which produced the Kansas City cassette standard might be a viable proposition. We at MicroLogic would be most anxious to participate in such a venture.

James D. St. John
MicroLogic
PO Box 55484
Indianapolis IN 46220

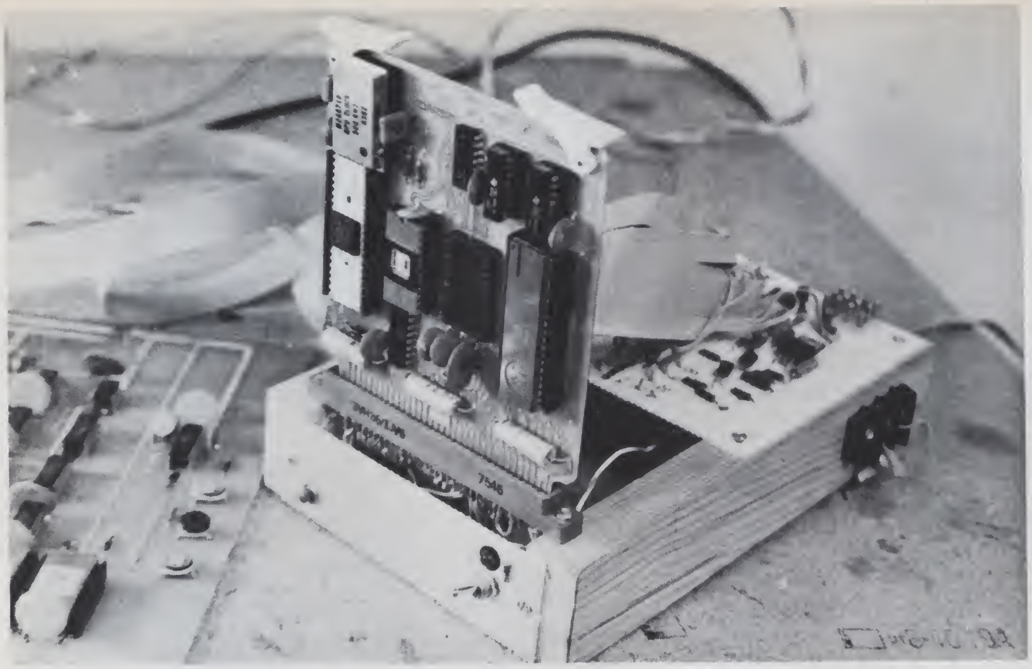
Thanks for the interesting letter, Jim. Regarding unfavorable letters from readers concerning manufacturers (and that includes our advertisers) . . . we publish them. But, we feel the manufacturer should have the opportunity to respond to such letter and we'll give them that opportunity before any letters are published. Personally, I think that business of differentiating between the Altair 8800 and 680 when discussing the Altair bus *is a cop-out of the few instances we've seen in the pages of KB where reference was made to the 680 bus was how to interface it to* an Altair bus memory board*! I'm looking forward to those articles and I share your enthusiasm for that Digital Group Phi-Deck system. – John.*

The Computer Room

Looks like a new member has joined the ever-increasing number of used computer equipment stores around the country. The Rondure Company's The Computer Room opened its doors to computer hobbyists in the Dallas area back in January. Since then, they've been offering a wide selection of used peripherals ranging from Selectrics to Teletypes, from high-speed tape readers to 80-column card readers and from dot matrix printers to multipart forms for printers. Aside from a selection of used minicomputers, they also have a number of micros in their microcomputer display area. What the heck, it's for sure their inventory is too varied and extensive for an attempt at listing it all! Take a look at the photos!

If you live in the Dallas area (or are just passing through) be sure and stop by and say hi to Stan Shannon and Bob Manna. Their address is: Rondure Company, The Computer Room, 2522 Butler, Dallas TX 75235, Phone: (214) 630-4621.

The Computer Room



The Sphere TPU/1 microcontroller disguised as a microcomputer system. (Note corner of Sphere CRT driver board.)

Jim Huffman
Hufco
PO Box 357
Provo UT 84601

Inside the Sphere Microcontroller

... intelligence for anything!

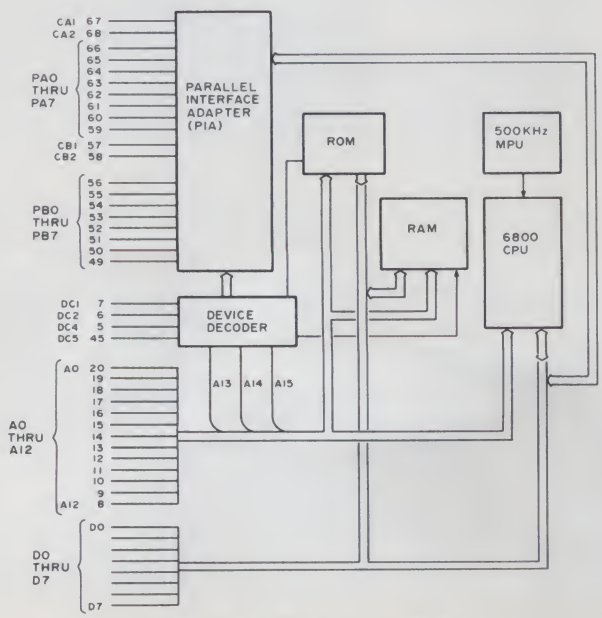


Fig. 1. Sphere TPU/1 block diagram.

Jim has taken a Sphere TPU/1, which was designed primarily for dedicated controller applications, and demonstrated that it has the capability for expansion into a full microcomputer system (which is not the case for all such boards). He's also provided extensive software which has some good general-purpose routines for checking out the board as a system.

Sphere is not going to be offering the TPU/1 as part of their line in the future. The new source for the board is: EnergeTech Corporation, PO Box 1437, Salt Lake City UT 84110, tel. (801) 531-0531. Cost of the board, assembled, is $194. – John.

The Sphere TPU/1 6800 based controller is a nifty little processor that, not by accident, is on a 4-1/4 x 4-3/4" PC board (precisely the same size as National's SC/MP Scamp). It's apparently intended as a replacement controller for applications that are a little more sophisticated. The TPU/1 contains a 6800 microprocessor, a clock chip (500 kHz), a 1702 EPROM (empty), a socket for another 1702 EPROM, a 7441, a 7400, a PIA, and two 2112s for 256 bytes of scratch pad memory. The one card TPU/1 comes out to a standard 72 contact (36 position) PC edge connector. It doesn't have on-board regulation, but that

possibly makes it even more versatile.

My test stand is shown in the photos; power comes from an 8 volt dc supply as well as a -12 volt dc supply which are both regulated on the test stand for +5 and -9. The negative voltage has been run as low as -5 volts without losing a thing. Also on the main board is an RS-232 interface that allows interconnection to terminals such as the CT1024. All in all, the Sphere TPU/1 is not a bad deal for $194, assembled and tested with one blank EPROM. A block diagram of the board is shown in Fig. 1.

The Software

Integrating a manufacturer's ready built microcontroller as a microprocessor is less trouble than you might expect. Consider the advantages; the hard part is done. All you have to do is connect up the TPU/1 to a memory board and you'll find it will operate with the greatest of ease. Software wise, it shouldn't be hard for a creative programmer to come up with an operating system that would give some limited debug functions. Later I have in mind writing a single EPROM program to service eight-bit parallel input data from a keyboard which would generate cassette tape and handle cassette tape input programs to load the operating system and debug software into RAM.

Using the programming that I've supplied with this article will require the use of two EPROMs. The advantage is that if you do not have facilities for burning EPROMs, Sphere will burn them for you for free if you order two EPROMs with your TPU/1 (I think the extra 1702 is less than $20). Order debug program "One Card V2.0". It's available in-house on PROM and they will merely be duplicating programs. The program listing shown here is a debug program. It has some features that are pretty nice, and it is easy to operate. It will also give you an operating system in your Sphere TPU/1 that will be Teletype compatible. Notice that this program runs at 110 baud. You may duplicate it in RAM somewhere and interface terminals at any speed merely by changing address DFF7 which contains a *magic number* that creates a software delay allowing 110 baud rate timing. Keep address DFF7 in mind if you're burning your own EPROM. It would be best to use a different command where you would be loading the contents of the accumulator with the contents of a register in the scratch pad memory or in the early part of memory, such as FE0000. Then in memory location 0000 and 0001, you could load the magic number that would allow Teletype interface. In order to do that you're going to need a routine that will allow keyboard interface, thus requiring no particular baud rate delay. That would be simple. During power up/reset have the PROM load the 011C for 110 baud into the memory position. Photo 1 is the test setup that I used for evaluating the TPU/1 processor.

Testing and Evaluation

What is needed from the outside world are the operating voltages: +5, -9, and ground, and depending on whether you're using Teletype or terminal, either RS-232 compatible driver circuit (Fig. 2), or Teletype interconnection system (Fig. 3). I've never tried the Teletype system, but it should work fine as it is merely a modification of Motorola's suggested circuit in the *Microprocessor Design Handbook*. Fig. 4 shows hookup for Southwest Technical Products' 4K RAM board as used in their SWTPC 6800 computer system. Note that no modifications were made to the PC board itself — merely in the way it interconnected to the microprocessor, data and address lines. Another

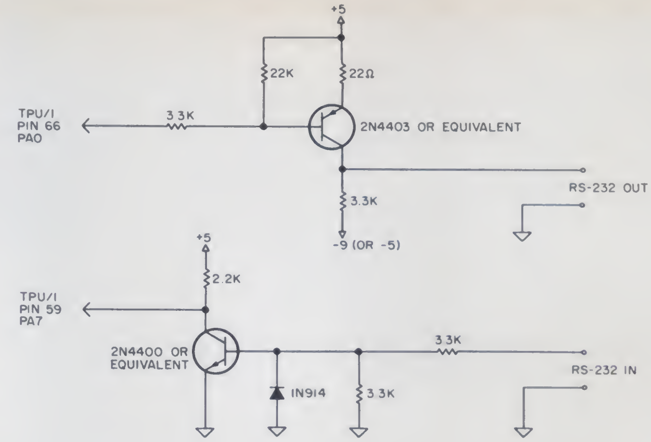


Fig. 2. RS-232 driver circuit.

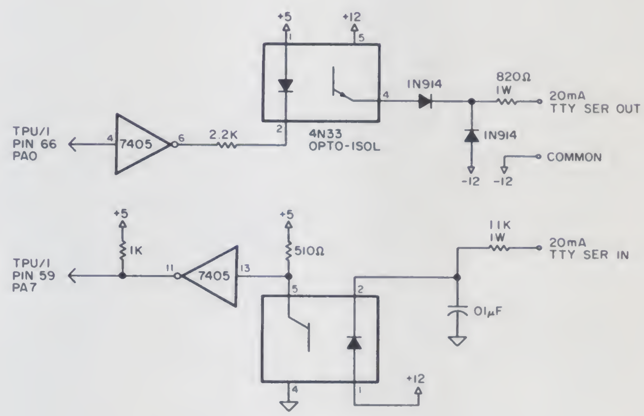


Fig. 3. 20 mA current loop TTY interface.

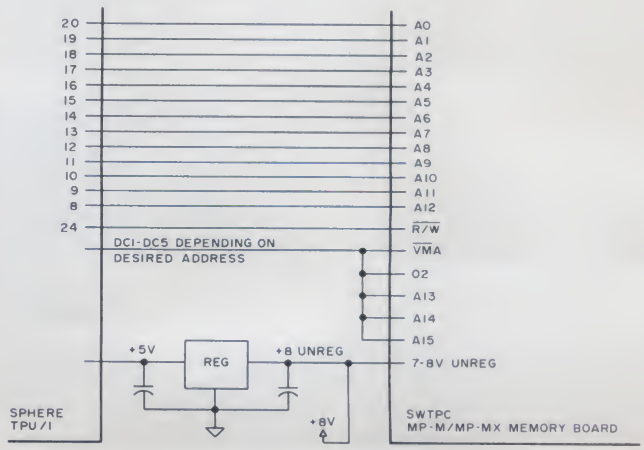


Fig. 4. SWTP 4K RAM interface to Sphere TPU/1.

board that I used for evaluation is the Sphere CRT circuit which has been advertised as CRTs PDQ.

Generally, I dislike the CRT driver. First, whenever I see a TTL printed circuit board with tons of by-pass capacitors, I figure that someone either didn't know what he was doing when he started the design or discovered he didn't know what he was doing once he'd gotten a little way along, and this one has a ton of 'em. Second, Sphere did not use any type of phase lock loop scheme to keep the horizontal sync signal locked to the 60 cycle ac line, so there's a little bit of ripple running vertically on the screen. Once you get used to looking at the wavy lines, it won't make you seasick. Another thing I didn't especially like about the Sphere CRT is that it did not use printed circuit edge connectors. It used 14-pin connectors and ribbon cable hookups, and that left something to be desired as I moved my *kluged-up* system around quite a bit. Treating the terminal as a memory position, however, proved to be very convenient. You are able to put cursors anywhere on the board and even do limited graphics by using the square cursor box to draw lines, outlines, figures, ect. But don't let the negative aspects of the Sphere CRT terminal detract from the possibilities of the TPU/1. It worked very satisfactorily under all conditions and was quite comparable to my SWTPC 6800 system.

Device	Hex Address	Binary			
PROM 1	E000-E0FF	111X	XXXX	VVVV	VVVV
PROM 2	DF000-DFFF	110X	XXXX	VVVV	VVVV
SCRATCH PAD	0000-00FF	000X	XXXX	VVVV	VVVV
PIA	6000-6003	011X	XXXX	XXXX	XXVV
DCI	2000-3000	001V	VVVV	VVVV	VVVV
DC2	4000-5000	010V	VVVV	VVVV	VVVV
DC4	8000-9000	100V	VVVV	VVVV	VVVV
DC5	A000-B000	101V	VVVV	VVVV	VVVV

Fig. 5. TPU/1 memory map.

Address SWTPC	Sphere	Function Name	Operation
0000-A000		RAM	MEMORY ADDRESSES
A000-A0XX		SCRATCH PAD	MEMORY ADDRESSES
E000-E1FF		ROM	MIKBUG OP SYST.
8000-801F		PIA	OUTPUT PORTS
E000		IO	I/O INTERE
E005		POWDWN	NMI SEQUENCE
E085		CHANGE	CHANGE MEMORY
E0AA		INHEX	INPUT HEX CHARACTERS
E0BF		OUTZH	OUTPUT Z HEX CHAR.
E113	(E013)	SFE	ENTER FROM SWI
E1AC	(E0BC)	INEEE	INPUT CHARACTER
E1D1	E0DC	OUTEE	OUTPUT CHARACTER

Fig. 6. SWTP memory masks.

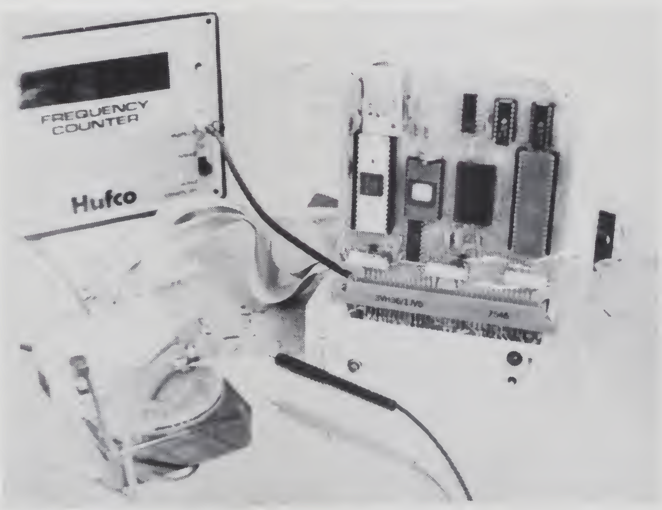


Photo 1. TPU/1 evaluation setup.

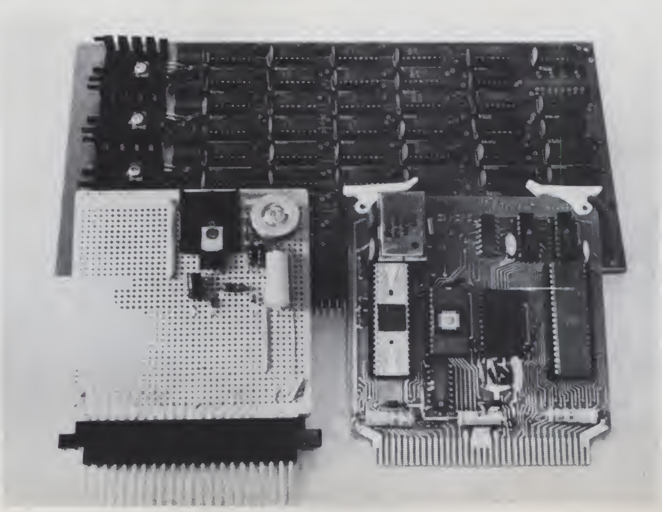


Photo 2. Next TPU/1 project — interfacing an Altair-compatible memory board.

In the Sphere TPU/1 they use a one-of-ten decoder as a one-of-eight decoder to come up with the addresses shown on the map in Fig. 5. Then they use a few of these addresses to run the scratch pad memory on-board, to operate the PIA, and for the EPROM. The rest of the memory address select signals are available at the output connector pins to be used to address up to 32K of memory. If one has a steady hand and a sharp razor blade, the tracks can be rearranged from the one-of-ten decoder to correspond to the addresses used in the SWTPC 6800 computer system (see Fig. 6). Let the ROM address be E000 to E0FF (no change needed). You may also address those same ROM positions by using E100 to E1FF. Then use D000 to D0FF to support the

things called at E1 and E0. The scratch pad RAM address could start with location A000 and the first available memory location 0000 with the PIA address at 8000. If one made these modifications, it should be possible to duplicate the functions of the MIKBUG ROM at the proper addresses in the TPU/1 ROM, and one could run such things as Southwest Technical Products' 8K BASIC on the Sphere TPU/1 computer!

Expansion and Future Projects

Photo 2 shows the basic parts for my next project. This project consists of interfacing a 4K Altair compatible (modified) RAM board to my TPU/1 board. A power supply, RS-232 connect/interconnect, and other outside world functions will be on the third board, which I'll call the I/O board. Thus, I'll have a three card computer system which I'll try to make address compatible with SWTPC software.

As far as I'm concerned, the real potential of the TPU/1 is highly understated by its manufacturer. Sphere claims the unit makes an excellent controller, somewhere down in the fine print they mention that it would make a good hobby computer. Personally I believe they have things turned around a bit. As a controller, it contains a sophisticated 6800 instruction set, and what a shame it is to allow that 6800 instruction set to be wasted controlling devices that could probably be done easier and cheaper by a one chip controller like SC/MP. However, as a hobby computer, the unit leaves little to be desired. Potential is there for expanding the system to very large proportions. In the back of my mind I'm envisioning 4K RAM boards on the same 4-1/4 x 4-3/4" size PC boards as the TPU/1. All this means is that I see the possibilities of a tremendously large system in a very small package. ■

Program A. A program for evaluation/operation of the TPU/1 controller as a computer system. Runs with 110 baud serial TTY I/O.

```
                  *
                  *
                  *
                  *
                  * ONE CARD COMPUTER DEBUGGER
                  *
                  * ↑B BREAKPOINT OPENED LOCATION
                  *
                  * ↑C CLEAR BREAKPOINTED LOCATION
                  *
                  * ↑E PERFORM RTI TO LOCATION WHERE
                  *      BREAKPOINT WAS
                  *
                  * G JUMP INDEXED TO OPEN LOCATION
                  *
                  * O OPEN LOCATION
                  *
                  * R OPEN LOCATION POINTED TO BY (SP+1)
                  **
                  * S SET STACK POINTER
                  *
                  * + OPEN NEXT LOCATION
                  *
                  * - OPEN PREVIOUS LOCATION
                  *
                  * SP (SPACE) CHANGE CONTENTS OF OPEN LOCATION
                  *
                  * CR (CARRIAGE RETURN) PERFORM!
                  *
                  * USABLE ROUTINES:
                  *
                  * PCOM; DISPATCHER INDEXED ON ACCUM'A              DF 03
                  *
                  * MSGOUT; PUTS OUT MESSAGE TERMINATED W/0          DF 3C
                  *
                  * CNTRLO; TYPES UP-ARROW BEFORE NORMAL CO          DF 68
                  *
                  * CASC; LOW NIBBLE OF ACC'A CONVERTED TO           DF 70
                  *      ASCII AND TYPED
                  *
                  * CO; CHARACTER OUT                                DF 7A
                  *
                  * DSPX; DISPLAY CONTENTS OF X IN HEX               DF 96
                  *
                  * CRLF; PERFORMS CARRIAGE RETURN-LINE FEED         DF A1
                  *
                  * DSPA; DISPLAY ACC'A IN HEX                       DF AA
                  *
                  * SPACE; TYPES ASCII SPACE NOTHING                 DF B7
                  *        MODIFIED EXCEPT COND'CODES
                  *
                  * INPNUM; TAKES HEX STRING PLACES                  DF CC
                  *         LAST FOUR DIGITS IN X
                  *
                  * INPCHR; GETS CHARACTER AND ECHOES                DF EC
                  *
                  * GDIGIT; GGETS SINGLE CHARACTER COONVERTS TO      DF FF
                  *         HEX OR RETURNS W/ CARRY SET
                  *
                            OPT      O,NOG
6000      TTYPID    EQU      $6000
6001      TTYPIC    EQU      TTYPID+1
011C      BAWD11    EQU      284
0020      SP        EQU      $20           ASCII SPACE
00F0      STAKTP    EQU      $00F0
00F1      PCVAL     EQU      STAKTP+1
00F3      XTMP      EQU      STAKTP+3
00F5      XTMPDL    EQU      STAKTP+5
00F7      SHDWR     EQU      STAKTP+7
00F9      BRKADD    EQU      STAKTP+9
003F      SWI       EQU      $3F
00FB      BRKSAV    EQU      STAKTP+11
E0F8      VECTOR    EQU      $E0F8
0D0A      LCRLF     EQU      $0D0A
F001      KBD       EQU      $F001
000D      CR        EQU      $D
000A      LF        EQU      $A
0023      HERALD    EQU      $#
001A      SUB       EQU      $1A
0002      STX       EQU      $2
0016      SYN       EQU      $16
```

```
DF00                  ORG      $DF00         Subroutine for lookup tables (GOto DF03)
DF00  08       PCOM2  INX
DF01  08              INX
DF02  08              INX
DF03  A1  00   PCOM   CMP  A   0,X           Compa with mem pointed to by IND (REG(X)
DF05  26  05          BNE      PCOM1         If not same GOTO DF0C.
DF07  EE  01          LDX      1,X           If equal put next two mem pos into X.
DF09  AD  00          JSR      0,X           Jmp to subroutine in "X".
DF0B  39       PCOM   RTS
DF0C  6D  00   PCOM1  TST      0,X           Does MEM -X have data?
DF0E  26  F0          BNE      PCOM2         Yes GOTO DF00 & look for another MEM-X
DF10  86  3F          LDA  A   #'?           No output A?
DF12  8D  66          BSR      CO
DF14  39              RTS
                               Subroutine For NMI Info (GOTO DF1E)
DF15  0D0A     MSGNMI FDB      LCRLF         Message — CR/LF
DF17  4E         .    FCC      /NMI @ / Message — NMI @ . . . .
DF1D  00              FCB      0             End of Message
DF1E  CE  DF15 SNMI   LDX      #MSGNMI       LDX with above message addresses
DF21  8D  19   ICOMON BSR      MSGOUT        Output message
DF23  30              TSX                    Put stack data into X
DF24  EE  05          LDX      5,X           LDX with PGM counter (5th in stack)
DF26  09              DEX                    DECR to PGM count start ADR
DF27  8D  6D          BSR      DSPX          Message = Data16 in X
DF29  20  2D          BRA      MONTOR        GOTO Monitor Pgm (IE., puts out prompt CHAR)
                               Subroutine for SWI (3F) info GOTO DF34
DF2B  0D0A     MSGSWI FDB      LCRLF         Message
DF20  53              FCC      /SWI @ / Message
DF33  00              FCB      0             End of Message
DF34  CE  DF2B SSWI   LDX      #MSGSWI
DF37  20  E8          BRA      ICOMON        GOTO DF21 & put out message
                               Outputs Message Starting at X (GOTO DF3C)
DF39  8D  3F   MO1    BSR      CO            Branch & output a Character
DF3B  08              INX
DF3C  A6       MSGOUT LDA  A   0,X           Puts first Byte in A
DF3E  26  F9          BNE      MO1           Is it a 0?
DF40  39              RTS                    Yes — Stop No — DF39
                                             SUBR for "RESET" GOTO DF48
DF41  BD  DFCC SS     JSR      INPNUM        SUBR for starting user program
DF44  08              INX
DF45  35              TXS                    Put the number entered in stack PTR
DF46  20  10          BRA      MONTOR        Go wait for commands
DF48  8E  00F0 SRESET LDS      #STAKTP       LDS with scratch pad ADR
DF4B  7C  6000        INC      TTYPID        Setup PIA
DF4E  86  04          LDA  A   #4
DF50  B7  6001        STA  A   TTYPIC
DF53  86  01          LDA  A   #1
DF55  B7  6000        STA  A   TTYPID
DF58  8D  47   MONTOR BSR      CRLF          Output CR/LF
DF5A  86  23   MNTR1  LDA  A   #HERALD       Put prompting Chara in A
DF5C  8D  1C          BSR      CO            Output A's data
DF5E  BD  DFEC        JSR      INPCHR        Jump to input A Chara
DF61  CE  E073        LDX      #MJTBL        Uses SUBR for lookup tables on
DF64  8D  9D          BSR      PCOM                   Looking for Debug Charas.
DF66  20  F2          BRA      MNTR1         Executes Debug functions as a SUBR-
                                             Out in E then loops back to DF SA
                                             & awaits more Debug functions.
DF68  36       CNTRLO PSH  A                 Control 0 entered
DF69  86  5E          LDA  A   #'↑
DF6B  8D  0D          BSR      CO            Output an "↑"
DF6D  32              PUL  A
DF6E  20  0A          BRA      CO            Output Chara in "A" (=B, see E097)
DF70  84  0F   CASC   AND  A   #$F           CONVERT TO ASCII
DF72  8B  30          ADD  A   #'0
DF74  81  3A          CMP  A   #'9+1
DF76  2D  02          BLT      CO            Then output Chara in A
DF78  8B  07          ADD  A   #7
DF7A  37       CO     PSH B                  Keep values of A & B
DF7B  36              PSH A
DF7C  0C       CO2    CLC                    CHARACTER OUT   Clear Carry
DF7D  8D  11          BSR      BO            Put out low start Bit
DF7F  C6  08          LDA  B   #8            Ready for 8 bits B=Bit counter
DF81  46       CL     ROR  A                 Move LSB of A into carry
DF82  8D  0C          BSR      BO
DF84  5A              DEC  B                 Decrement Bit counter
DF85  26  FA          BNE      CL            Not out of Bits? GOTO DF81 & do another
DF87  0D              SEC      Out-then sec carry (1st bit of stop)
DF87  0D              SEC                    Out-then sec carry (1st bit of stop)
DF88  8D  06          BSR      BO
DF8A  0D              SEC                    Set carry (snd stop Bit)
DF8B  8D  03          BSR      BO
DF8D  32              PUL  A                 Restore A & B & end SUBR
DF8E  33              PUL  B
DF8F  39              RTS
                *              Bit Out SUBR
DF90  79  6000 BO     ROL      TTYPID        Put Carry in Bit 0 of PIA
DF93  8D  5D          BSR      OD            Go for one Bit delay
DF95  39              RTS                    End SUBR
                *              Print Contents of Index Register
DF96  DF  F3   DSPX   STX      XTMP          Keep X
```

```
DF98  96  F3                 LDA  A   XTMP        LDA W MSB
DF9A  8D  0E                 BSR      DSPA        Output MSB
DF9C  96  F4                 LDA  A   XTMP+1      LDA W LSB
DF9E  8D  0A                 BSR      DSPA
                   *                  Output A CR/LF
DFA0  39                     RTS
DFA1  86  0D       CRLF      LDA  A   #CR
DFA3  8D  D5                 BSR      CO
DFA5  86  0A                 LDA  A   #LF
DFA7  8D  D1                 BSR      CO
DFA9  39                     RTS
                                      Display Contents of ACC A in HEX
DFAA  36           DSPA      PSH  A
DFAB  44                     LSR  A )
DFAC  44                     LSR  A |    Shift 4 BITS
DFAD  44                     LSR  A |
DFAE  44                     LSR  A )
DFAF  BD  DF70               JSR      CASC        ½ Byte ACC A Typed
DFB2  32                     PUL  A
DFB3  BD  DF70               JSR      CASC        Other ½ Byte ACC A Typed
DFB6  39                     RTS
                                      Output A Space on TTY
DFB7  36           SPACE     PSH  A
DFB8  86  20                 LDA  A   #SP
DFBA  8D  BE                 BSR      CO
DFBC  32                     PUL  A
DFBD  39                     RTS      Enter A HEX String
DFBE  8D  0C       ENTER     BSR      INPNUM
DFC0  DF  F3                 STX      XTMP
DFC2  DE  F1                 LDX      PCVAL
DFC4  96  F4                 LDA  A   XTMP+1
DFC6  A7  00                 STA  A   0,X
DFC8  BD  DFA1               JSR      CRLF
DFCB  39                     RTS      Places last Four Digits in Index Regis
DFCC  4F           INPNUM    CLR  A
DFCD  5F                     CLR  B
DFCE  36           I1        PSH  A
DFCF  8D  2E                 BSR      GDIGIT Gets Single Digit of HEX
DFD1  24  07                 BCC      12
DFD3  37                     PSH  B
DFD4  30                     TSX                  Put B on Stack
DFD5  EE  00                 LDX      0,X         Put Stack in X
DFD7  31                     INS
DFD8  31                     INS
DFD9  39                     RTS
DFDA  30           I2        TSX
DFD8  68  00                 ASL      0,X
DFDD  59                     ROL  B
DFDE  68  00                 ASL      0,X
DFE0  59                     ROL  B
DFE1  68  00                 ASL      0,X
DFE3  59                     ROL  B
DFE4  68  00                 ASL      0,X
DFE6  59                     ROL  B
DFE7  AA  00                 ORA  A   0,X
DFE9  31                     INS
DFEA  20  E2                 BRA      I1
DFEC  8D  4E       INPCHR    BSR      CI          Input Character From TTY
DFEE  BD  DF7A               JSR      CO
DFF1  39                     RTS
DFF2  8D  00       0D        BSR      HD          ONE BIT DELAY Achieve by Two HD's or
DFF4  DF  F5       HD        STX      XTMPDL                    "Half" Delays
DFF6  CE  011C               LDX      #BAWD11     "Magic Number" Bit Delay @ 110 B
DFF9  09           DL        DEX
DFFA  26  FD                 BNE      DL          Is X counted to Zero No? Continue
DFFC  DE  F5                 LDX      XTMPDL
DFFE  39                     RTS
                   *                  Brings in Character & Converts to HEX
DFFF  8D  EB       GDIGIT    BSR      INPCHR
E001  80  30                 SUB  A   #'0    )
E003  25  0F                 BCS      GD1    |
E005  8B  E9                 ADD  A   #$E9   |
E007  25  0B                 BCS      GD1    |
E009  8B  06                 ADD  A   #6     }    ASCII/HEX CONVERSION
E00B  2A  04                 BPL      GD2    |
E00D  8B  07                 ADD  A   #7     |
E00F  25  03                 BC5      GD1    |
E011  8B  0A       GD2       ADD  A   #10    )
E013  0C                     CLC
E014  39           GD1       RTS
                                      Clear Break point
E015  86  43       CC        LDA  A   #'C         Put C in ACC A
E017  BD  DF68               JSR      CNTRLO      Go put out C ↑
E01A  DE  F9                 LDX      BRKADD      Put Breakpoint (SWI) ADDR in "X"
E01C  96  FB                 LDA  A   BRKSAY      Get Pre Breakpoint Data
E01E  A7  00                 STA  A   0,X         Put original Data Back
E020  DF  F1                 STX      PCYAL
E022  20  06                 BRA      001
                                          Space (Data Entry)
```

```
E024   8D    91     00      BSR       SPACE
E026   8D    A4             BSR       INPNUM
E028   DF    F1     002     STX       PCVAL
E02A   BD    DFA1   001     JSR       CRLF        Output CR/LF
E02D   BD    DF96   003     JSR       DSPX        Display where X Register is (same
E030   BD    DFB7           JSR       SPACE          as PC ADDR)
E033   A6    00             LDA  A    0,X
E035   BD    DFAA           JSR       DSPA
E038   BD    DFB7           JSR       SPACE       Outputs Data at Address followed by SP
E03B   39                   RTS
                                      Input Character
E03C   7D    6000   CI      TST       TTYPID      Waits for serial data
E03F   2B    FB             BMI       CI          Got It? Then —
E041   8D    B1             BSR       HD          Half bit delay and —
E043   7D    6000           TST       TTYPID      ReSample
E046   2B    F4             BMI       CI          If data present bit is good
E048   37                   PSH  B
E049   C6    08             LDA  B    #8          Set up for 8 bits
E04B   8D    A5             BSR       OD          Delay 1 bit
E04D   0D                   SEC
E04E   79    6000           ROL       TTYPID      Put input bit state in carry
E051   46                   ROR  A                Move bit into A
E052   5A                   DEC  B                Next Bit
E053   26    F6             BNE       IL          Last Bit? Yes —
E055   8D    9B             BSR       OD          delay one bit
E057   7D    6000           TST       TTYPID      Test Stop Bit End
E05A   2A    E0             BPL       CI
E05C   84    7F             AND  A    #$7F        And A with 0111 1111
E05E   33                   PUL  B
E05F   39                   RTS                   End
E060   30           RR      TSX       Examine Registers in Stack
E061   08                   INX
E062   08                   INX
E063   08                   INX
E064   08                   INX
E065   20    C1             BRA       002         Go Display X
                                      + Key Depressed
E067   DE    F1     PLUS    LDX       PCVAL
E069   08                   INX
E06A   20    03             BRA       MIN2
                                      — Key Depressed
E06C   DE    F1     MINUS   LDX       PCVAL
E06E   09                   DEX
E06F   DF    F1     MIN2    STX       PCVAL
E071   20    B7             BRA       001         Go Display X
E073   02           MJTBL   FCB       2           CONTROL B
E074   E097                 FDB       BB
E076   03                   FCB       3           CONTROL C
E077   E015                 FDB       CC
E079   05                   FCB       5           CONTROL E
E07A   E0A9                 FDB       EE
E07C   47                   FCB       'G
E07D   E0BC                 FDB       GG
E07F   4F                   FCB       '0
E080   E024                 FDB       00
E082   52                   FCB       'R
E083   E060                 FDB       RR                      Looks At Data
E085   53                   FCB       'S                      Input on Keyboard
E086   DF41                 FDB       SS                      Format
E088   2B                   FCB       '+                      XX      Data
E089   E067                 FDB       PLUS                    XXXX    SUBR ADDR
E08B   2B                   FCB       '—
E08C   E06C                 FDB       MINUS
E08E   0D                   FCB       CR
E08F   DFA1                 FDB       CRLF
E091   20                   FCB       SP
E092   DFBE                 FDB       ENTER
E094   00                   FCB       0
E095   DF0B                 FDB       PCOM3
                                      Insert Breakpoint
E097   86    42     BB      LDA  A    #'B         Go output ↑B
E099   BD    DF68           JSR       CNTRLO      Put P.counter value in X
E09C   DE    F1             LDX       PCVAL       LDA A with P.C. LSB
E09E   A6    00             LDA  A    0,X         Keep A
E0A0   97    FB             STA  A    BRKSAV      Put A 3F in A
E0A2   86    3F             LDA  A    #SWI        Stuff A in ADDR pointed to BY X
E0A4   A7    00             STA  A    0,X         Keep X
E0A6   DF    F9             STX       BRKADD      END
E0A8   39                   RTS
                                      Go Start Program Where SWI Was
E0A9   86    45     EE      LDA  A    #'E
E0AB   BD    DF68           JSR       CNTRLO      Output ↑E
E0AE   31                   INS
E0AF   31                   INS
E0B0   31                   INS                   Move Stack Pointer to Pre-
E0B1   31                   INS                      Interrupt value
E0B2   30                   TSX                   Put Stack Value in X & Vice Versa
```

```
E0B3    6D    06              TST    6,X
E0B5    26    02              BNE    EE1
E0B7    6A    05              DEC    5,X
                                              Back up PGM counter
E0B9    6A    06      EE1     DEC    6,X
E0BB    3B                    RTI
                                              Return from interrupt (starts PGM)
                                     Start Program at "X"
E0BC    DE    F1      GG      LDX    PCVAL    Put program counter value in X
E0BE    6E    00              JMP    0,X      Jump to program counter ADR & Run
E0F8                          ORG    VECTORS       program.
E0F8    00F7                  FDB    SHDWR
E0FA    DF34                  FDB    SSWI
E0FC    DF1E                  FDB    SNMI     Vectors Where each function is sent.
E0FE    DF48                  FDB    SRESET
                      *V 1.2
                              END

TOTAL ERRORS 00000
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KB CALENDAR

Phoenix

The Arizona Computer Society is a group of Phoenix area computer hobbyists holding regular meetings on the second Tuesday of each month from 7 to 10 PM at room 226, De Vry Institute, 4702 N. 24th St., Phoenix AZ. We have approximately 150 persons on our mailing list and attendance at our regular meetings runs between 40 and 70. For further information contact the Arizona Computer Society, PO Box 14391, Phoenix AZ 85063.

Boston

A new club is being formed in the metropolitan Boston area. As of this writing, the Boston Computer Society holds its meetings at the Commonwealth School, 151 Commonwealth Ave., Boston, an area well served by public transportation. Any interested persons may contact Peter Nelson at (617) 237-9537 or Richard Gardner at (617) 354-1216.

Indianapolis

The IEEE Computer Society of Central Indiana will sponsor a microcomputer show Wednesday, July 20 from 1:00 PM to 9:00 PM at the Holiday Inn located at I-70 and Shadeland Avenue. There will be exhibits, demonstrations, and technical seminars. Attendance is free to all.

Columbus

Meetings of the Amateur Computer Society of Columbus are held the first Wednesday of every month at the Center of Science and Industry, beginning at 7:30 PM. For further information contact Fred Hatfield, Computer Data Systems, 1372 Grandview Avenue, Columbus OH 43212, (614) 486-3347.

CORRECTIONS

Corrections

In "Super-Tube" (March, page 124) the following corrections to diagrams and text were brought about by an oversight in the row cursor operation called to the author's attention by Mr. Scott Eckert, 22 Stoneybrook Mobile Terrace, Lee Center NY 13363.

Change the last sentence that begins on the bottom of page 125 to read: "Instead of incrementing/decrementing IC29, ICO gets the current row count value from IC29 and IC9, is then incremented/decremented, and then 600 ns later, the new row count value is reloaded back into IC29 and IC9." Change Fig. 2 on page 125 as shown, and add Fig. 2a.

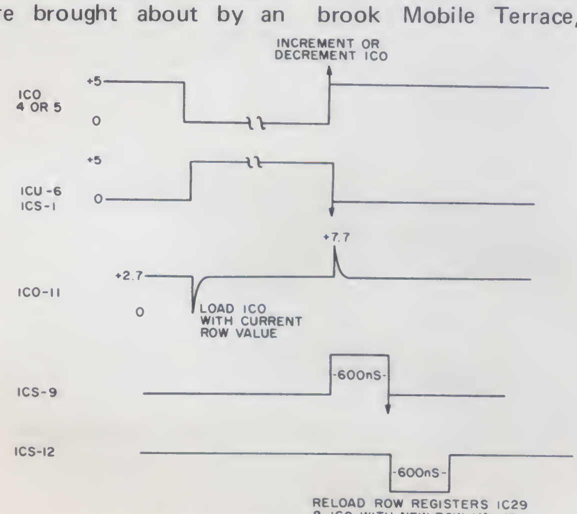
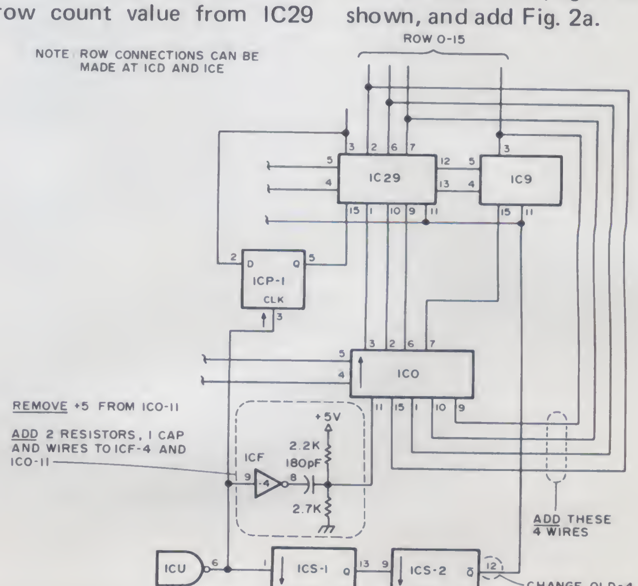


Fig. 2a. Timing Chart



Changes to Fig. 2.

Grant Runyan
1146 Nirvana Road
Santa Barbara CA 93101

The Great TV to CRT Monitor Conversion

A computer that can't talk back is certainly not much fun, and unless it can talk back in English it's a poor companion. An English-speaking output device such as a Teletype or a line printer is expensive, noisy, and uses lots of paper. The ideal talk-back device for a computer is a video display. Even though a computer has a hard copy printer, a tape punch, and a magnetic tape system, it should have a video output for simple interactive operation.

A number of video display generators have now become available and are reasonably priced. Whichever video system you choose, whether it be the original TVT-1 or one of the newer and better ones, you will need a cathode-ray tube (CRT) monitor for the display. If you are loaded with cash, you can simply go to the local computer store and buy a good monitor. However, then you would have only a monitor, and you couldn't watch a TV show in your computer shack with it at all. You also will have spent some cash unnecessarily and not have had the fun of making an ordinary TV work.

In my opinion, the ideal plan is to convert a TV for your monitor. The original hobbyists' TVT-1 generates a modulated radio frequency signal which carries the video information. It simply attaches to the antenna terminal of a TV set, can be tuned to an unused channel, and the display comes on the screen. That system turns out to be very unsatisfactory, and the FCC takes a dim view of it. Even the TVT-1 has provision for taking the video signal directly into a monitor and disabling the rf generator. The modification of an ordinary TV for video input seems ideal for a hobbyist. That modification consists of arranging to put the video signal directly into the video amplifier.

Author's CRT monitor.

Almost any model TV that you attempt to modify will require a slightly different arrangement, and some TVs will be much easier to modify and work better than others. Before you start to modify any set, be sure it has a transformer type power supply. If it does not, forget it because it can quickly burn out all your expensive digital equipment.

Of all the sets on the market, the one that I have found to be the most desirable is the 12-inch Hitachi. It is the model P-04 and has the Hitachi SX chassis. It is inexpensive and has a very wide bandwidth so that you can expect a sharp display with a line width of up to 80 characters. Discount appliance stores sell this model for around $80, which is certainly reasonable for a quality monitor. The SX chassis is also used on models P-03, P-05, P-08, P-53, P-63, S-47, and several others.

When you buy a Hitachi set it will not have a schematic in the package, but, if you wish, you can get a Sams Photofact folder 3, set 1501 which has the complete picture, schematics, etc. You will not need the schematics, however, with the information which follows. You will simply need to install a switch to disconnect the video *amplifier* from its normal input and switch it to

the interface circuit in Fig. 1.

Modification Instructions

To make the modification to the Hitachi 12" TV, lay the set on its face on a surface of soft material such as a polyfoam pad. Pull off the brightness and contrast control knobs. The back can be easily removed by taking out seven screws. Remove the two screws holding the antenna connector block (where an external antenna would be connected). Remove five screws holding the back in place. There are two screws on the bottom, one on each side, and one inside the handle. The back should now lift off easily, but do it carefully. The set can now be placed upright, but it will have to be supported by a block of wood placed under the metal frame that holds the transformer. Otherwise the circuit board will be damaged.

Build the interface circuit on a piece of perfboard about 2½ inches square. It can be mounted on the metal frame which holds the transformer by using two small right angle brackets. Use shielded cable to run the signals from all points to the switch. Note that there is a flat area on the back cover for the set on the side opposite the normal antenna connection. This is an ideal place to mount your switch and a connector for the incoming video signal. Keep the signal leads short by pulling the switch and connector into position and fastening after the back cover has been replaced. On the inside of the cover there is a boss which must be removed from the flat area. Cut it off with a short piece of hack saw blade or with a hot knife.

To make the necessary connections to the TV set place it on its face on a pad and look at the underneath side of the circuit board. Near the center of the bottom of the board there is a metal shield covering an area about one inch square. A supporting leg at the right of the shield is soldered to the circuit board. In the vicinity of this leg is the point where the foil of the circuit board is to be cut. Refer to Fig. 2 for the diagram of the area. After cutting the foil, carefully solder the shielded cable going to the knife of the switch to point A and the shielded cable going to one side of the switch to point B. The leg of the metal shield is the place to solder the shields of the cables and the negative ground supply line for the modification. In about the center of the circuit board there are two pads with a line between them and the letters SG251. Connect a 10 pF capacitor between these two pads. This improves the operation with contrasted displays.

In the upper left-hand corner of the TV circuit board there is a hole through which all wires from the bottom of the board to the top may be passed. Near the hole there is a power transistor mounted on a heat sink. The heat sink is soldered to the TV circuit board on a large pad directly beneath it. This is the pad from which to take the +11.4 volt supply which goes to the voltage regulator of the modification.

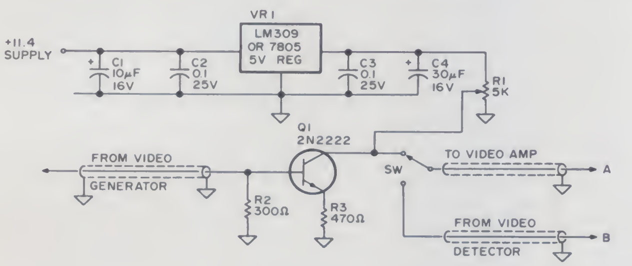


Fig. 1. TV video interface.

Adjustments

When everything is properly connected but the back has not been replaced, stand the TV upright again being careful to support it underneath the bracket and not damage the circuit board. Connect the video generator and place the switch for normal TV reception. If a picture appears everything is probably all right and you can throw the switch for video input. Some adjustment of the contrast and brightness will have to be made, and the potentiometer on your modification will have to be adjusted. This adjustment is quite critical for the best display. Approximately 4.4 volts on the arm of the pot will be about correct.

If the display is too large in the vertical direction, use an alignment tool to adjust the vertical size and vertical linearity controls until size is correct and lines of characters at the top of the screen are the same size as those at the bottom.

If the display is too large in the horizontal direction, your video generator may have an adjustment to correct that. If it does not, use a plastic alignment tool to adjust the slug in the coil mounted on the neck of the picture tube. Turning the slug to the right reduces the size of the display. Be careful not to turn the slug too far or force it.

When the display is the correct size it may still not be properly centered on the screen. Centering can be accomplished by adjusting the two flat metal rings on the back of the yoke coil around the neck of the picture tube. The metal rings each have a little tab with which to turn them. Use a plastic tool for this. Be very careful in working around the picture tube to not damage it or yourself. Very powerful shocks can be gotten from the picture tube which would cause you to jump and possibly hurt yourself or the equipment. This can occur even after the set has been turned off for a long period of time. When you replace the cover on the set, note that the circuit board slides into two channels inside the cover.

In Summary . . .

Be aware that making this modification voids the manufacturer's guarantee. If the set gives you trouble, you may have to pay for repairs unless you can convince the service facility that your modification has not caused any malfunction. Also, when this set is plugged into the power circuit, it will be drawing current even though the front switch is turned off. Consumption is about four Watts, and that's about thirty-six kilowatt hours in one year. For those who are conservation conscious that will cost about $1.50 a year, and you will want to plug your monitor into an outlet that switches off when the computer is not operating.

If you do not like to build little modifications yourself, or if it is a problem or inconvenience to obtain the necessary parts, there is a very nice kit available to modify this very set. It is slightly more sophisticated than this circuit, but in my opinion, it does not produce materially better results. It is the Pickles & Trout TV Mod Kit and can be obtained from Pickles & Trout, P.O. Box 2276, Goleta CA 93018 or from your local computer store. The price for everything complete including the PC board is $20. Full instructions and parts as well as an alignment tool and necessary cables and connectors are furnished. ■

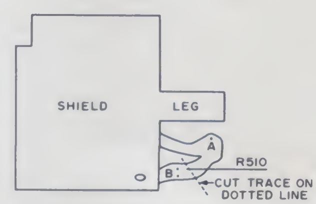


Fig. 2. Shield area of circuit board.

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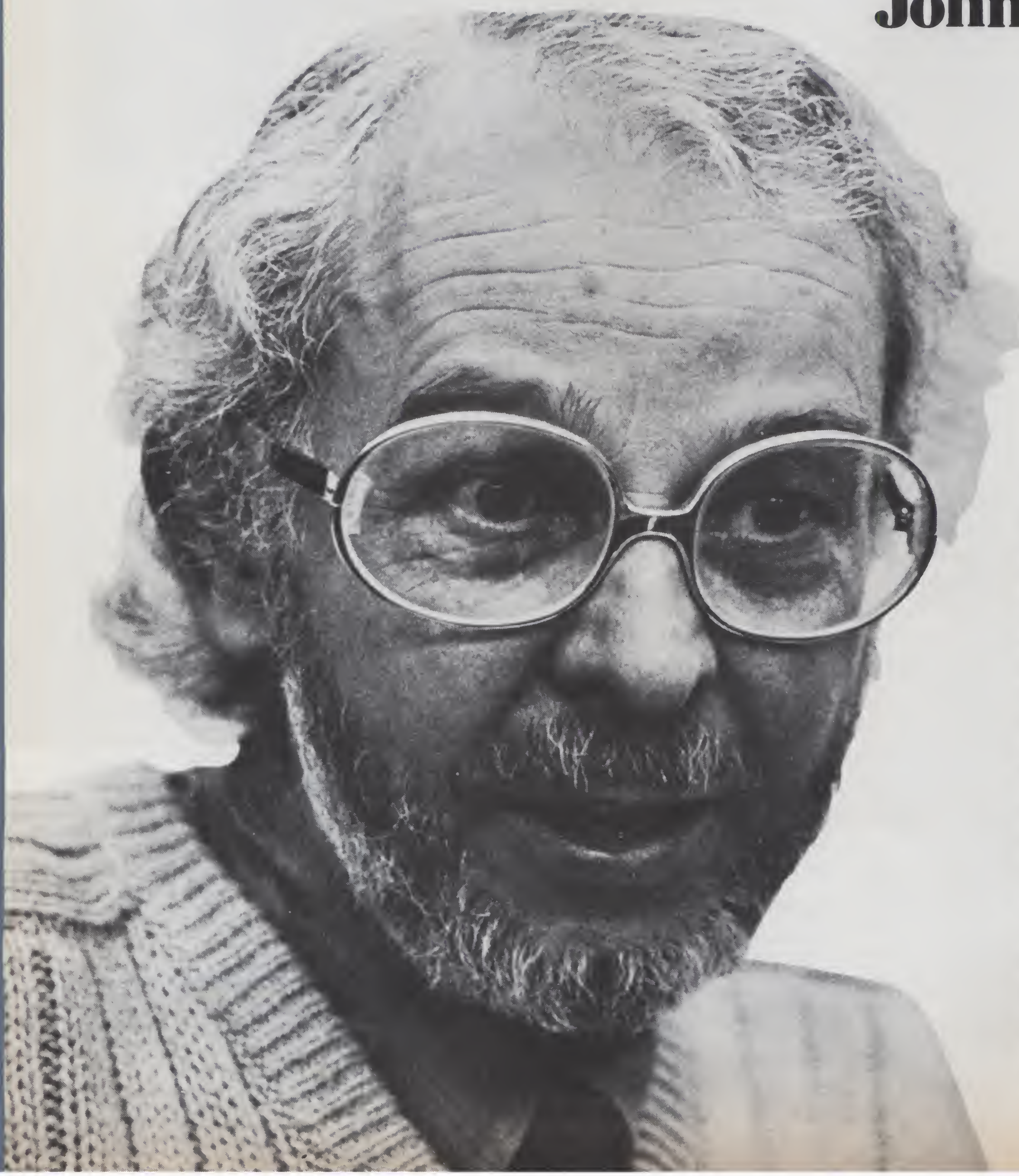
Computer Turns Director

. . . an interview with John Whitney



Sheila Clarke
Cybergrafix
PO Box 430
Glendale CA
91206

Having known John Whitney through his contributions to *SCCS Interface Magazine*, and being somewhat familiar with his work in film, I became enthusiastic when he revealed that he's working on another film which is being developed via computer. John's articles rarely discussed computers per se, nor did they really talk about graphic arts or filmmaking. His articles were usually puzzling because they discussed music theory as it related to motion picture graphics. And my mind was left foggier on the subject as a result. Perhaps it's just me . . . and then again, others might have shared my confusion. But John, being the patient teacher, agreed to spend time toward my further enlightenment.

First, for those who have not had the delight of seeing films by John Whitney, a bit of background is in order. His work was displayed on a video monitor at the MITS Convention in Albuquerque in March, 1976. His latest and most frequently shown film, *Arabesque*, was screened at a special SCCS gathering in May, 1976, at the Academy of Motion Picture Arts and Sciences. Commercial work included film titles for *Glass Bottom Boat, Vertigo* and others, numerous television titles, and special graphics for commercials. The processes John Whitney invented have become a part of the film industry's craft. His Slit-Scan process was used in *2001, A Space Odyssey* to create the illusion of moving through a science fiction "time warp."

John takes little pleasure or pride (so it seems) in the fact that his work has contributed significantly to the art of animated titling and he has continued his search for the basic principles by which we all may explore and create design imagery which is music to the eye. Supported by research grants, his tools include camera, film, computer and original music.

CLARKE: John, reading your articles one might get the feeling of viewing a 12 inch slice out of a 12 foot wall mural. Even though we understand what we feel when listening to music or watching one of your films, the two together as a single concept is a difficult one. Where are you coming from and where are you going with your alignment of music to motion and light?

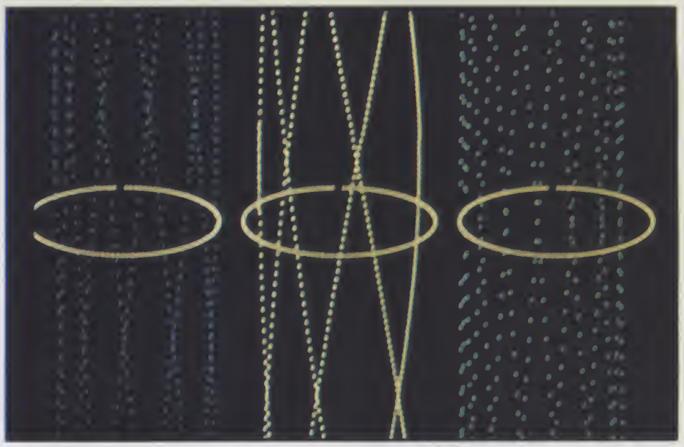
WHITNEY: One difficulty is just the oddness. I'm talking about a visual art form that is very new and unique, and is certainly in no way a common experience. It's difficult to describe something that is unlike anything else . . . there's nothing to relate it to. All of the uniqueness will disappear sometime soon though. The video disk and its availability in one's home will very quickly eliminate the strangeness about "putting on" a record to see, as well as hear, music.

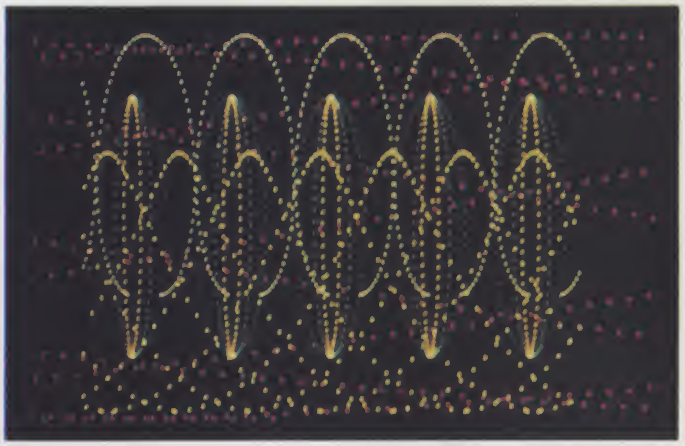
CLARKE: Did your career begin with an interest in music?

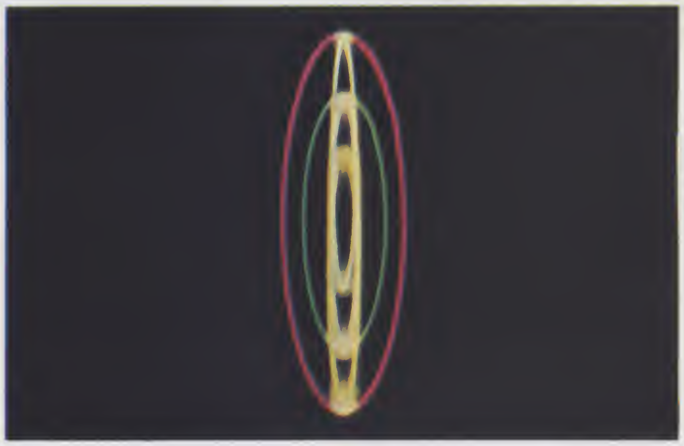
WHITNEY: Yes. In college when I began to think about my future career, I aspired to be a composer. At the same time I couldn't quite reconcile that with another area of interest. I was aware then, and felt strongly that I was a child of the 20th century and I couldn't quite see myself taking up a career in traditional music, in light of the fact that in the late '30s there were already musical sound tracks and electronic possibilities. Another conflict with music was my pleasure in filmmaking. I made elapsed-time films of a lunar eclipse in my college astronomy class. So I was intrigued with those possibilities. I was very ambitious to become involved with creative filmmaking.

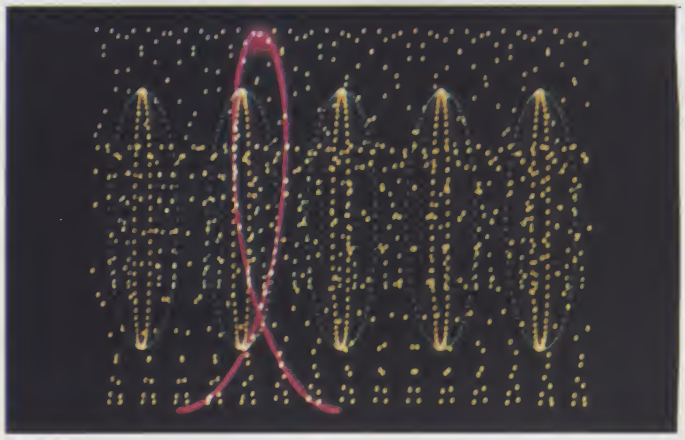
CLARKE: Continuing with the uniqueness of your art, can you describe your philosophy?

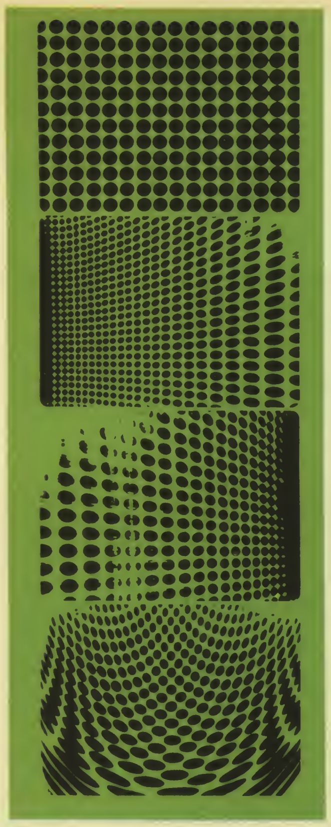
WHITNEY: I became involved with making films before World War II, and started slowly developing animation mechanisms because I'd reached the conclusion that the art of hand animation was not the art I was interested in. Hand animation seemed like some sort of art that was best used to tell jokes or nursery tales. I began to realize that I was trying to do something that hadn't been invented yet. In fact, it's an interesting point that Frank Lloyd Wright saw some of my films and commented that "here was an art that was icing for a cake that hadn't been baked." Today I realize more deeply than ever his extraordinary foresight. In a sense I was aspiring to do the impossible, namely abstract motion design before computers were invented. By the '50s I was working on something one could call a computer, though I didn't











Spacial motion in depth is the result of the Slit-Scan process combined with zoom.

A single, perfect sphere becomes swirling multiples by adding the zoom cycle with strobing nine times per cycle. This piece was produced for a milk commercial in 1964.

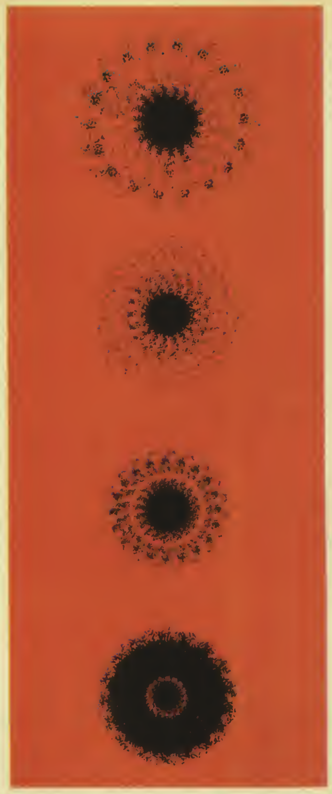
call it that. Here I was trying to build a machine out of war surplus mechanisms which I didn't understand, and only gradually I realized that those were the first computers. Originally those mechanisms were among the very first analog devices, and WW II was the first time cybernetics was applied to solve complex mathematical problems, namely ballistics (fire control problems).

CLARKE: And how does the computer play a role in filmmaking?

WHITNEY: For an example look at the use of musical instruments when creating music. I'm much closer to the traditions of the musician or composer than I am to the graphic artist or painter. The computer, for me, is an essential instrument. There's no other way dynamic visual material can be created. I'm involved with new concepts of harmonics which only date from the last ten years. It is only possible to think of the dynamic visual image in connection with harmonic relationships through use of a computer. Harmonics have to do with periodicity, and with mathematical foundations of image-making. These patterns can only be created by use of a digital device. All of my concern is with design that is possible through derivation of mathematical roots in Pythagorean geometry.

CLARKE: Is the process a matter of assigning specific values to musical tones?

WHITNEY: Yes. My visual work is like that. Music does have specific values. You can't play a wrong note in music, and you always know when an instrument is out of tune. What does "out of tune" mean? It means that the tuning is imprecise, out of alignment or stretched, more or less, in terms of thousandths of an inch precision. So tonality is an exceedingly precise thing. We think of music as a purely human matter of love, life and death, and all of the human emo-



Example of random dots, rotating to create an orderly pattern.

Using the Slit-Scan process, the slit is set to move a full width of the type as the type moves north and south one or more times per half cycle. The return phase is completed while the shutter is closed. The preset differential drift creates the illusion of underwater undulation.

tions. But what lies behind it is a mathematical precision that is absolutely exact. What comes out of this hard mechanical, mathematical precision is excellence of music. The result is the greatest, most intense of emotional experiences . . . it's *human*. That same relationship applies in terms of computer graphics. It seems mathematical, cold and hard nosed, and shirt-sleeve engineering. This is a very common misconception.

CLARKE: Going back to your beginnings, how did you support yourself until you began to make films professionally?

WHITNEY: It's been very difficult. I began to think of this kind of film while I spent a year in Paris in 1939. That's when I first started making abstract films. Then for a time the war distracted from all those things. But I began to make films again as soon as I got home. During the war I had midnight defense jobs and was able to make films at the same time.

After the war I imagined that this kind of visual art would have great possibilities for television. I expected I would be able to make a living doing films and having them shown on television. I received a Guggenheim Fellowship in 1947 and '48. I expected by the time I'd had two years of concentrated supported effort I would be able to produce the kind of film that would be popular on television. But in fact there was just no market for my work at all. So it was one job after another trying to keep alive and raise a family. From time to time I applied my capabilities doing such things as television commercials and film titles. By the late '50s I was fairly successful and had my own studio. More and more I applied the animation techniques I was inventing relative to this kind of visual art. Yet it's always been, and is still, necessary to have artist's grants to continue.

CLARKE: How have you obtained grants?

WHITNEY: As my reputation has progressed, my ability to make appropriate proposals to the right sources has come along with it.

I'll explain that old equipment you see in my studio this way: I slowly began to realize that this equipment represented the forerunner of the digital computer, so I was encouraged to write a proposal to IBM in 1965. With the IBM grant I started using computer graphics. And that's what I've been using ever since by means of generous support from industry and foundations.

I think there's recognition nowadays that this type of creative work deserves support. But that too is changing. The video disk for television was demonstrated at USC in March. Think of the possibility of publishing works on video disk. One of the MCA vice presidents demonstrating the video disk pointed out that even a publication run of 10,000 copies will be profitable enough so a film such as I'm able to make might sell for $5 to $10. Today I must sell a film for $100 to $150. Even though my work on video disk may never have a mass audience, there certainly will be an audience as broad as one that buys piano sonatas. These films may never be a top hit record, but that is no longer a desirable goal.

CLARKE: You are now an instructor at UCLA. Since you are operating under a grant, or fellowship, where does your teaching career come in?

WHITNEY: It makes it possible to go on now. Teaching, for a composer or someone in the arts, is often very good because it provides a base of income and leaves time available for creative work. I find it very rewarding, too. I teach a couple of classes at UCLA and am slowly introducing computer graphic equipment for the art department school of design which is completely separate from the cinema and theater arts departments.

I'm also becoming associated with International College. This is an interesting project. International College restores the original concepts of the "university" as they were at the time of the founding of universities in Europe. The program involves top specialists who tutor privately or in small groups under contract with the student . . . well-known people such as Yehudi Menuhin (violin), Buckminster Fuller (Comprehensive Anticipatory Design Science), Bertrand de Jouvenel (Futuristics), and other noted writers, historians, political scientists, social scientists and artists. These people are listed in the catalog, and if one wishes to have personal tutoring, he applies as he would at any university.*

CLARKE: What type of equipment will you and your students be working with?

WHITNEY: I have a very complete motion picture studio here for film processing and editing. It will be even more complete when I obtain the computer equipment, which will be soon. I haven't really settled on the final system I'll keep for my studio use, but throughout last fall I had a 4051 Tektronix desk top smart terminal with graphics display and 32K additional memory.

Now I own a 4002 Tektronix graphics terminal which I bought secondhand. I'm leaving the options open because better systems are being developed all the time that will soon cost under $5,000. Better mass storage and memory improvements are coming along. Now I'm testing and examining various small systems I could own myself.

CLARKE: Now let's talk about your current work.

* A brochure from International College may be obtained by writing 1019 Galey Avenue, Los Angeles, California 90014.

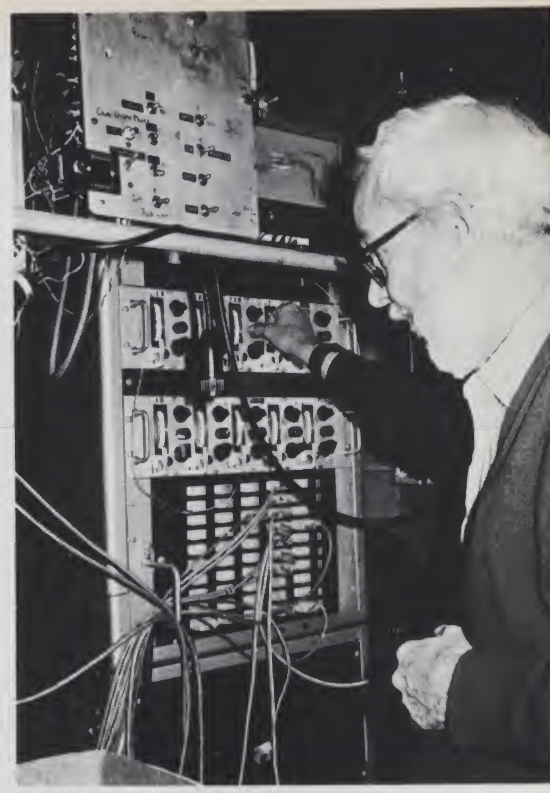
WHITNEY: I am well into the production of a film under a research grant from the National Endowment for the Arts, though I'm nowhere near finished. There are vast areas of this film about which I have no real understanding yet. It's a creative process that grows very slowly. The first part of the film was done at my studio with the 4051 Tektronix computer. My work on this little computer helped me lay the foundation of image material for the film. The software was programmed in BASIC by two of my associates. Now I'm doing the remaining work at Information International Corporation's facilities, using their FR 80 with a 35mm camera.

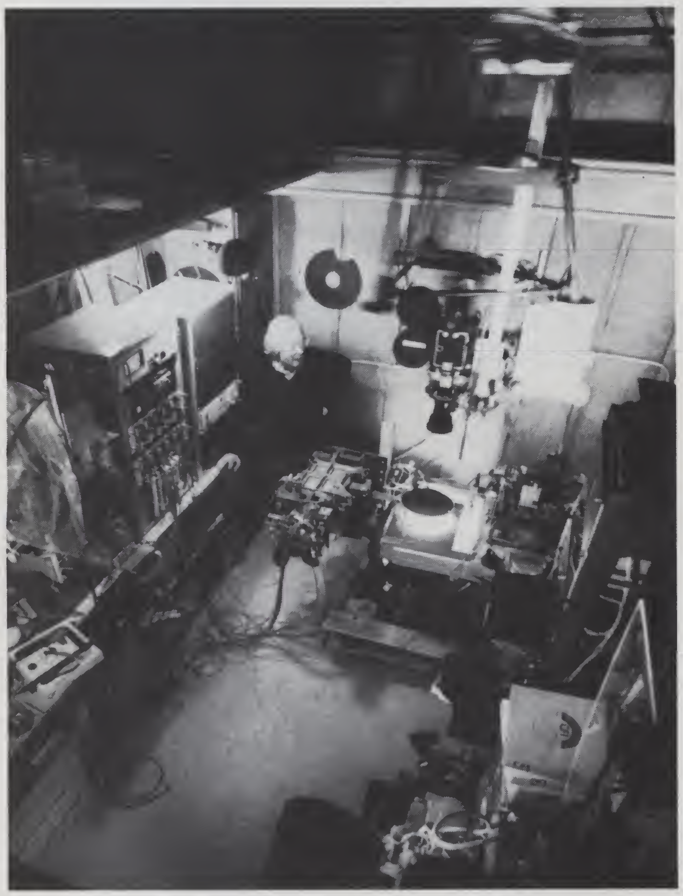
The concept of the film is derived from pattern material similar to that used in *Permutations* which I completed in 1968. I have always wished to return to that material (circular polar coordinate patterns) because there were many areas of design quality there which I thought could be much more subtly and carefully explored.

CLARKE: How will the new film differ from *Permutations*?

WHITNEY: It involves taking advantage of all the advances in technique and creative skills which I have acquired over the last ten years. I began in the mid-60s with an IBM research grant. I was using about $3 million worth of equipment at the UCLA Health Science computer facility — one of the largest centers in the United States at that time, rivaling the Pentagon. My activities were considered lowest priority and I worked during the midnight hours.

With the extraordinary technological advances in the last ten years, I can revisit the design areas that were explored in *Permutations* with many times the sensitivity to the control and dynamic processes involved. In fact, back then, using





Upper left: John Whitney describes the control process which he developed to produce this symmetrical pattern. This original oil is the result of a mechanically controlled release of oil paint onto the surface.

Right: Studio equipment must be reconfigured to meet the specifications of each new filming project. This is how John's studio looked in March. John explains, "The 35mm camera looks down on the illuminated artwork directly underneath. With lettering on the rotating table and the shutter in an open position, and while the artwork rotates one cycle, the strobe flashes and all images appear in one frame. When the artwork turns one cycle the camera automatically advances one frame."

Lower left: John Whitney's studio in 1970, including the original analog machine he used to control the motion of artwork to be filmed. The device is an adaptation of a World War II mechanical analog problem solver. John modified it in the early '60s long before he'd considered computer graphics. The totally integrated system is driven by servo motors, with an amplifier and servo follower system. This allows manipulation through the camera and film overhead.

those millions of dollars worth of equipment, I was only able to generate one picture every five to six seconds, so it was not a real-time technology. Now with the National Endowment Grant matched by support at Information International in Culver City, I've been able to explore the same design material in real time.

CLARKE: What equipment do you use?

WHITNEY: Information International's FR 80. I do the basic programming with a PDP-10 and film it on the FR 80.

CLARKE: Can you describe the artistic philosophy behind your films?

WHITNEY: One of the problems I've become evermore deeply concerned about in terms of the visual experience of this type of dynamics, or pattern in motion is this: All the work done by so-called animators and abstract film-makers has never shown anything approximating the kind of great elegance of pure metrical or rhythmic organization which is common in music. Among composers, Mozart may have been the most profoundly sensitive to the subtleties of rhythmical organization and timing. You really have to be a very accomplished pianist before you can perform most of Mozart's keyboard work because of the subtlety and precision of his composition.

In the motion picture field on the other hand, film critics have often talked about editing as if it were a kind of music. Eisenstein for instance, wrote about this extensively — about the concept that cutting and timing were based on a musical foundation. But that's very, very imprecise and careless . . . that's an offhand way of talking about

it. Because there has never been anything to compare with the precision, the subtlety and sensitivity of metrical organization that has characterized music.

Now however, with the computer and its control, we have periodic harmonic relationships in computer graphics; we're right on the threshold of opening up a new kind of visual rhythmic experience.

CLARKE: What do you think about the Lasarium?*

* An animated, light/music show using laser light projected thru color filters onto a planetarium dome.

WHITNEY: I think about the Lasarium the way I think about the film *Fantasia*. These are extraordinarily popular. *Fantasia* is the most popular of the Disney films, I believe. There are features about this type of film that are quite wonderful. Stravinsky, on the other hand, who contributed one piece of music to the film, absolutely hated *Fantasia* and all of Hollywood. Why should there be something so terribly popular, and at the same time, so terrible in some ways. It's hard to understand. Disney's *Fantasia* is a mix of frontier, stretching to reach this kind of visual precept I speak of. Yet it falls miserably short in many ways.

The same holds true for the Lasarium. It's pretty nearly formless in some ways, yet it does present a great splash of color and activity. In the cases of both, one of the features characteristic of this visual experience prevails. You have a lot of splashy color and a very good sound track. The traditional appeal of the color carries you along, and all that is done is a gilding of what is already very gilt by way of a musical experience. This is Hollywood and showmanship. But I proffer something else.

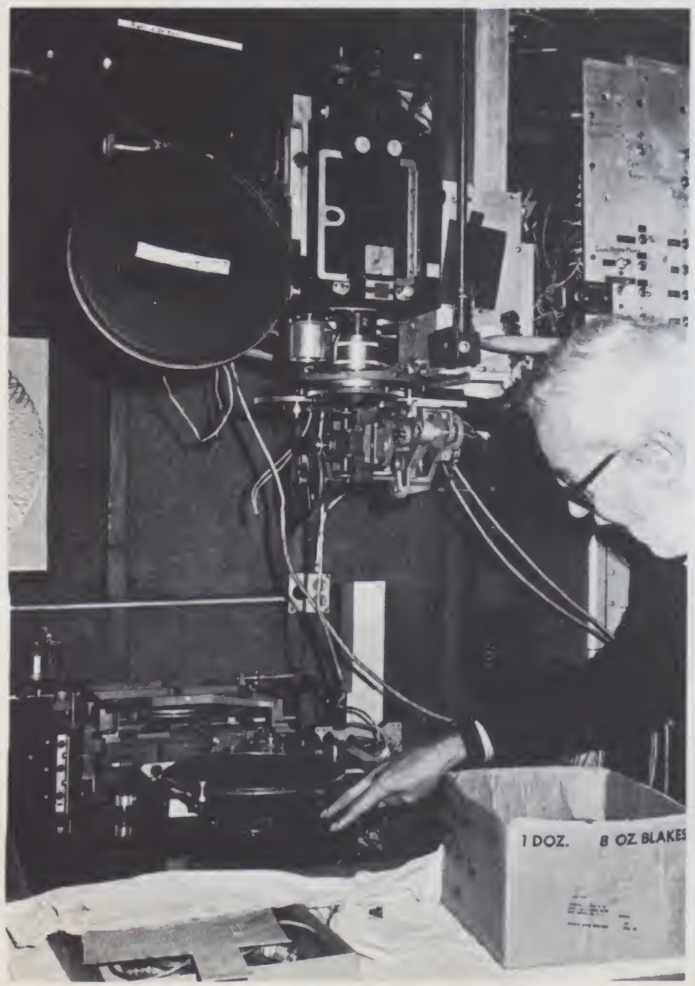
CLARKE: In other words, those media have not achieved a coordination of music and video as a dynamic unit?

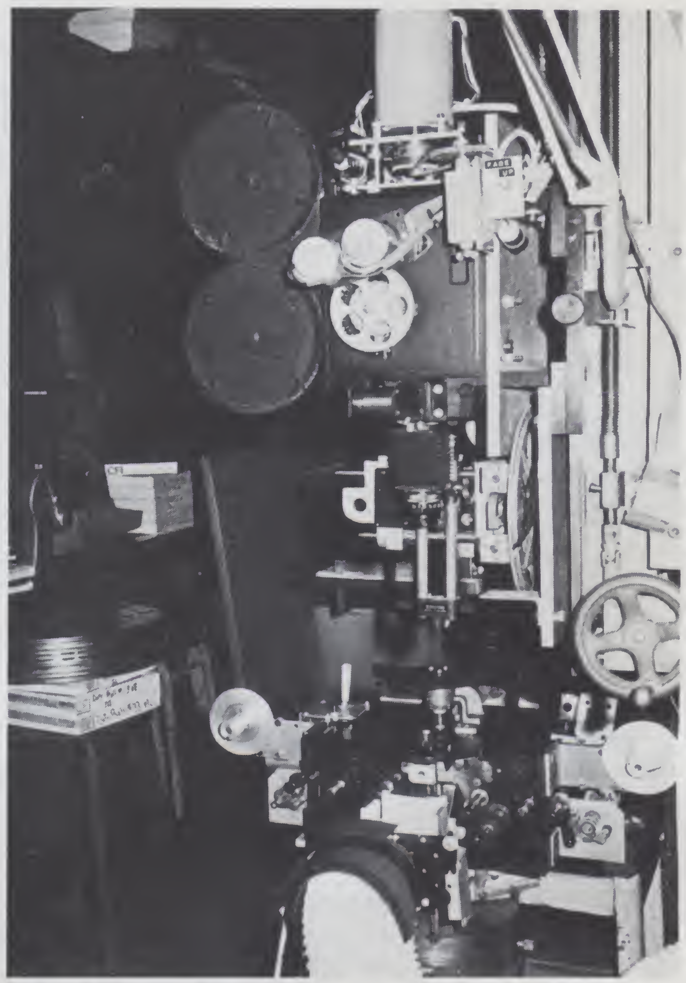
WHITNEY: That's exactly right. Actually, I aspire to achieve that and I expect that a time will come when a visual experience will be moderately popular — as popular as a symphony orchestra, and will affect people deeply, emotionally in a way that we cannot imagine now. In a way that will be a magnitude more effective than anything you see now at the Lasarium.

CLARKE: Tell us about the music soundtrack for your films.

WHITNEY: Each film required a different musical solution. For my earlier films

Below: If the artwork is circling in a small pattern, one frame of film captures many images at once, or a soft blur, depending on the artwork. If the art consists of fine lines, a multiple pattern of symmetrical lines results. The mechanism may be changed to move vertically while the artwork moves back and forth, which results in the same image appearing several times in several sizes in each frame.





Above: All motion may be controlled through rotating axes, X and Y coordinates, zoom lense, and a process called Slit-Scan. In this process John makes a light slit with black paper, then scans the lettering straight across as the art moves up and down. The result is a smooth, wavy motion or undulating of lettering. This technique was used for the title Glass Bottom Boat *and with a zoom for the effects in* 2001 Space Odyssey.

I composed the music myself (those efforts won for John and his brother James a first prize in 1949 at the First Belgium International Film Festival). For *Arabesque* I asked an Iranian master musician, Manoocheher Sadeghi, to extemporaneously perform his music as he watched the film. The same improvisational technique was used to accompany *Matrix* by concert pianist Doloris Stevens.

I'm now looking forward to the many developments in microprocessor technology that foretell composing computer music and image with equal ease and speed.

CLARKE: You've often been asked, and you might answer here, why you do not explore simultaneous generation of design and music through a computer.

WHITNEY: They must be achieved separately so that there can be a meaningful dialogue between the music and motion picture graphics.

CLARKE: How would you sum up art and technology?

WHITNEY: Much has happened in the last ten years. I have my own equipment in my own studio. I've made a few successful films. And in 1968 I talked about the day when a computer in the home would be the size and price of a television set. It happened.

John Whitney must be admired for the unmapped path he has chosen, for his originality, artistic sensitivity and for his discipline. Although his art has no name one will emerge, just as the fruits of his discipline will entertain, perhaps move us. Computers will aid in substantial changes in the art forms that are familiar today and will introduce new ones for home television and home computers. It becomes clearer each time we explore the subject, however, that they can never replace the artist. ■

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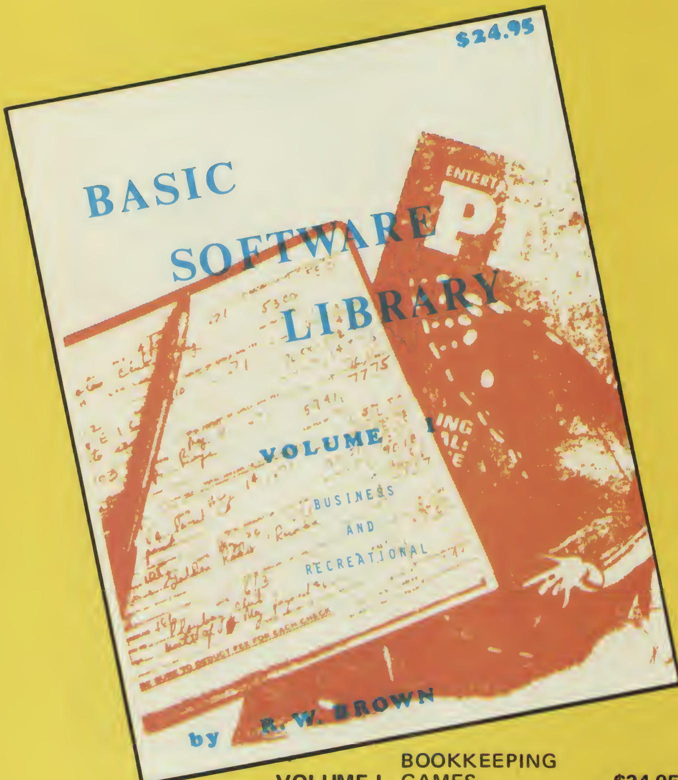

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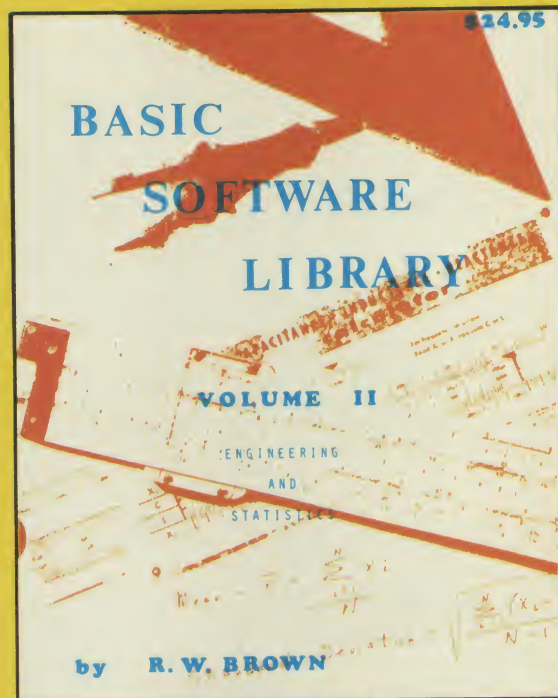

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STOP BY OUR BOOTH (e615) AT THE SAN

The Random Number Game

This program was written for the SWTP 6800 computer with a CT1024 CRT terminal and 4K BASIC.

The games of Quadgt and Bagels in *What To Do After You Hit Return* got me started on this one. In *101 Basic Computer Games* the games of Bulcow and Bagles are also of the same variety.

The object of the game is to guess a random number which has been generated by the computer. The human player has the option of deciding how many digits this number will contain. With each guess the computer

Herman DeMonstoy
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correct digits in the correct place

correct digits in the wrong place

```
TTY RUN

THIS IS 'THE NUMBER GAME'. WANT
INSTRUCTIONS (1=YES, 0=NO)? 1
I WILL THINK OF A NUMBER WITH
THE AMOUNT OF DIGITS YOU ASK
FOR. THEN YOU INPUT THAT MANY
DIGITS, WITH COMMAS BETWEEN.
I WILL RESPOND WITH 2 NUMBERS.
THE FIRST, CORRECT DIGITS IN
THE CORRECT PLACE. THE SECOND,
CORRECT DIGITS IN THE WRONG
PLACE. TO STOP, PUT 10 IN FOR
THE FIRST DIGIT. GOOD LUCK.
HOW MANY DIGITS ? 4
TYPE 4 DIGITS, NONE ALIKE
             ?    1,2,3,4
1    1       ?    1,5,6,7
0    2       ?    4,5,3,2
0    1       ?    6,7,1,4
0    2       ?    4,2,7,8
1    2       ?    7,2,8,1
 CORRECT IN ** 6 ** TRYS
PLAY AGAIN (1=YES, 0=NO)? 1
HOW MANY DIGITS ? 8
TYPE 8 DIGITS, NONE ALIKE
        ? 1,2,3,4,5,6,7,8
0  7    ? 2,3,4,5,6,7,8,9
2  4    ? 10,3,4,5,6,7,8,9
SORRY TO SEE YOU QUIT.
THE NUMBER WAS
0 3 1 2 6 8 5 7
PLAY AGAIN (1=YES, 0=NO)? 0
BYE. HOPE YOU HAD FUN.

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prints out a number indicating the number of correct digits in the correct place in your guess. It also prints out a second number which indicates the number of correct digits in the wrong place. Needless to say, the fewer guesses necessary to determine the computer's number will result in the highest score. The game was written so you can pick the number of digits from 1 to 10 but I find 3 to 7 to be the most interesting.

The cursor controls for the terminal must be used to start a new frame when the instructions are started and at the start of each game. The left space is used to put the results back on the same line as the guess. The fact that the cursor control is a wrap around control allows the use of seven "cursor lefts" to put the results at the end of the guess. These are in the quotation marks of line 610. A "home up" and "erase EOL" is after the first quotation mark in lines 80 and 400. This starts a new frame for the instructions and at each new game. A control U is in each CR/LF of the 4K BASIC, and I use this as "erase EOF." This clears the entire frame on the second line.

There are two necessary changes to use this program with a Teletype terminal. They are as follows:

```
Add     405 PRINT "     ";
Change  610 PRINT I;" ";J;
```

The 5 spaces in line 405 will put the first guess in the same line as the rest. Line 610 will now print the results in the next line, followed by the second guess. This leaves the results of guess one in the line with guess two. This must be kept in mind while playing. All instructions and statements were written for the 32 spaces of the CRT terminal. These can be much longer for a Teletype.

I hope this game is as popular at your house as it is here. ■

```
0010    REM 'THE NUMBER GAME' — TV
0020    REM BY H. DEMONSTOY 12-9-76
0030    PRINT "THIS IS 'THE NUMBER GAME'. WANT"
0040    PRINT "INSTRUCTIONS (1=YES, 0=NO)";
0050    INPUT Y
0060    IF Y=0 GOTO 200
0070    IF Y<>1 GOTO 40
0080    PRINT "I WILL THINK OF A NUMBER WITH"
0090    PRINT "THE AMOUNT OF DIGITS YOU ASK"
0100    PRINT "FOR. THEN YOU INPUT THAT MANY"
0110    PRINT "DIGITS, WITH COMMAS BETWEEN."
0120    PRINT "I WILL RESPOND WITH 2 NUMBERS."
0130    PRINT "THE FIRST, CORRECT DIGITS IN"
0140    PRINT "THE CORRECT PLACE. THE SECOND,"
0150    PRINT "CORRECT DIGITS IN THE WRONG"
0160    PRINT "PLACE. TO STOP, PUT 10 IN FOR"
0170    PRINT "THE FIRST DIGIT. GOOD LUCK."
0199    REM GET NUMBER OF DIGITS
0200    PRINT "HOW MANY DIGITS ";
0210    INPUT N
0299    REM SET UP THE NUMBER
0300    FOR I=1 TO 10
0310    A(I)=I-1
0320    NEXT I
0330    FOR I=1 TO N
0340        K=INT (10*RND(0))+1
0350        T=A(I)
0360        A(I)=A(K)
0370        A(K)=T
0380    NEXT I
0390        K=0
0399    REM GET THE GUESS
0400    PRINT "TYPE ";N;"DIGITS, NONE ALIKE"
0410    ON N GOTO 1100,1120,1140,1160,1180,1200,1220,1240,1260,1280
0450        I=0
0460        J=0
0470        K=K+1
0499    REM CALCULATE THE RESULTS
0500    FOR E=1 TO N
0510    FOR F=1 TO N
0520    IF A(E)=B(F) GOSUB 1000
0530    NEXT F
0540    NEXT E
0550    IF B(1) >9 GOTO 800
0599    REM PRINT RESULTS
0600    IF I=N GOTO 900
0610    PRINT "";I;" ";J
0620    GOTO 410
0800    PRINT "SORRY TO SEE YOU QUIT."
0810    PRINT "THE NUMBER WAS"
0820    FOR I=1 TO N
0830    PRINT A(I);
0840    NEXT I
0850    PRINT
0860    GOTO 910
0900    PRINT " CORRECT IN ** ";K;" ** TRYS"
0910    PRINT "PLAY AGAIN (1=YES, 0=NO)";
0920    INPUT X
0930    IF X =1 GOTO 200
0940    PRINT "BYE. HOPE YOU HAD FUN."
0990    END
1000    IF E=F THEN I=I+1
1010    IF E<>F THEN J=J+1
1020    RETURN
1100    INPUT B(1)
1110    GOTO 450
1120    INPUT B(1),B(2)
1130    GOTO 450
1140    INPUT B(I),B(2),B(3)
1150    GOTO 450
1160    INPUT B(1),B(2),B(3),B(4)
1170    GOTO 450
1180    INPUT B(1),B(2),B(3),B(4),B(5)
1190    GOTO 450
1200    INPUT B(1),B(2),B(3),B(4),B(5),B(6)
1210    GOTO 450
1220    INPUT B(1),B(2),B(3),B(4),B(5),B(6),B(7)
1230    GOTO 450
1240    INPUT B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8)
1250    GOTO 450
1260    INPUT B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8),B(9)
1270    GOTO 450
1280    INPUT B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8),B(9),B(10)
1290    GOTO 450
```

Cassette Interface First Aid

... use your processor to set timing

Denis R. Bourdeau
7984 W. Quarto Ave.
Littleton CO 80123

```
COUNTER    MVIA 000       SPACE (001 for MARK)
           OUT 001        to cassette interface

START      LXIH 000000    initialize count
           MVIB 100       mask for 7493 bit

ONWAIT     IN 003         wait until off if on
           ANAB
           JNZ ONWAIT

OFFWAIT    IN 003         wait until on if off
           ANAB
           JZ OFFWAIT

ON         IN 003         count until off
           INXH
           ANAB
           JNZ ON

OFF        IN 003         count until on again
           INXH           (29 cycle loop)
           ANAB
           JZ OFF

           CALL OUTHL     display count
           JMP START      from the top again
```

Table 1. Software used by the Digital Group 8080 System.

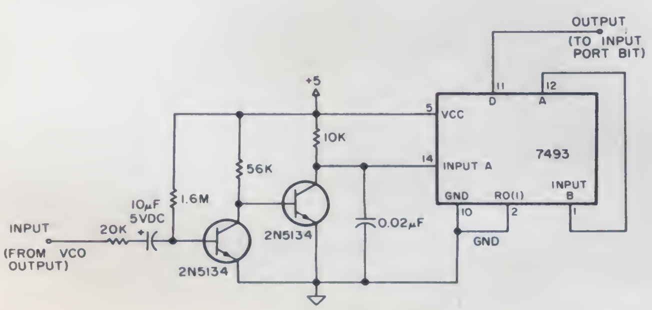

Fig. 1. Schematic of buffer counter circuit.

Here is an accurate method of calibrating the FSK circuitry commonly used in cassette interfaces. Usually, the voltage-controlled oscillator (VCO) used to generate the MARK and SPACE frequencies involves two trimmers that permit calibration. Generally, the filters used to generate a serial bit stream from cassette playback have relatively fixed center frequencies so that the calibration required has to do with the VCO only.

A frequency counter is a natural device to use for frequency calibration but is not cheap or common. *The processor driving the cassette interface is a much more available item!* A trivial buffer/counter in combination with a short piece of software allows convenient and precise calibration. It is not unreasonable to expect the processor cycle-time to be an accurate time-base since it is almost always crystal-controlled.

This scheme, in essence, consists of squaring up the audio FSK waveform, dividing it down to get accuracy, and finally, interfacing the resultant pulses to an input port for software pulse counting.

The buffer/counter consists of a two-transistor amplifier feeding a 7493 4-bit counter. This device, in my system, translates a 0.5 volt peak-to-peak triangle wave into a clean TTL pulse-train at one-sixteenth the input frequency. Fig. 1 shows the circuit used.

The software performs four simple functions: (1) setting the VCO frequency, (2) waiting until the pulse starts, (3) counting each pulse occurrence, and (4) displaying the resultant count to the user.

The Digital Group 8080 System (the system I use) uses the software shown in Table 1.

Calculation of the actual and theoretical count is not difficult. There will be, however, some small variation in the displayed count due to the nature of the digital counting process and the non-ideal, circuituous (pun) total signal path.

Examination of the software shows that each 7493 or HL count is worth 29 cycles or 14.5 microseconds. Since a 2975 Hz (SPACE) frequency has a 336 microsecond period, 16 periods requires 5380 microseconds. Each 7493 pulse, therefore, occurs for 371 counts at this frequency. Similarly, the MARK frequency, 2125 Hz, causes pulses separated by 519 counts. Obtaining the SPACE/MARK frequency ratio shows that the count ratio must be 1.4 exactly.

Note that one count out of 371 is considerably better than 1% accuracy. Actual performance of the hardware resulted in an occasional one-count variation for the SPACE and a three-count variation for the MARK. ■

Understand Your Computer's Language

. . . a look at instruction sets

Several people have asked for an article describing the differences, advantages and disadvantages of the various instruction sets. We've also had requests for definitions of the different addressing modes. Lance has done a good job of covering both topics in the following article. – John.

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Emulative Systems Co.
PO Box 1258
Rancho Santa Fe CA 92067

The Processor Technology SOL, an Intel 8080-based computer.

The instruction set is one of the most important features of any computer. It not only describes what the computer can do in one cycle, but it also determines how easy the computer is to program and how well-suited it is to particular tasks. However, instruction sets are surprisingly difficult to compare or evaluate. Different computers have very different instruction sets and users soon find that each one has its own advantages and disadvantages. This article will describe instruction formats, and discuss the addressing methods used to fetch data and store results. A continuation will present some of the types of instructions and criteria that users should consider in comparing instruction sets.

Instruction Formats

During each instruction cycle, the CPU needs a large amount of information. The amount of this information that is included in the instruction itself determines the flexibility of the computer and the number of instructions that will be necessary to perform simple tasks. The required information is:

1) The operation to be performed. This operation may be an arithmetic or logical function, a data transfer, a selection among alternate instruction sequences (i.e., a conditional or unconditional jump), or a change in processor status (e.g., enabling or disabling interrupts).

OPERATION CODE FIELD	ADDRESSING METHOD FIELD	ADDRESS FIELD

Note that although the figure shows the fields as consecutive groups of bits, they do not have to be. For example, the Intel 8080 commonly uses both ends of the word (bits 0 to 2 and bits 6 and 7) as the operation code.

Fig. 1. A typical instruction format.

2) The source of the data to be used. The operation may require two numbers (like an addition), one number (like a shift), or none at all (like a halt).

3) The destination of the result. Presumably the CPU will place the result somewhere for later use.

4) The source of the next instruction. This source may depend on past or present results.

Fig. 1 shows the format of a typical instruction. If, for example, the instruction results in the addition of two numbers, the various parts of the instruction (or *fields*) must somehow tell the computer:

1) That the operation is an addition.

2) Where to get the two numbers to add.

3) Where to place the result.

4) What to do next.

Clearly not all of this information can be part of the instruction. Otherwise, the instruction would require several words of program memory and could not be easily moved from the memory to the CPU. For example, if four bits are necessary to select an operation and 12 bits to choose each address, an addition instruction would be 52 bits long (since two source addresses, a destination address, and a next instruction address must all be specified). Some information, therefore, must be independent of a particular instruction, i.e., must be *implicit*. However, we will also need a way to change this implicit information or to perform tasks within the fixed framework.

We want the instructions to be as short as possible since the computer must fetch the instruction before it can do anything else. Longer instructions require more memory accesses. One of the great advantages of 16-bit processors over 8-bit processors is that 16 bits is often enough for a complete instruction. Therefore 16-bit processors can spend less time fetching instructions and more time doing useful work. This is in addition to the fact that 16-bit processors handle twice as much data in each cycle.

Each instruction must, of course, specify which operation the computer will perform. Typical choices include ADD, SUBTRACT, COMPARE, SHIFT, LOAD, STORE, JUMP, and CALL. The part of the instruction which contains this information is the *operation code field* or *op code*. The number of bits in the instruction which are reserved for the operation code determines the number of separate operations allowed in the computer. Table 1 shows the relationship; each extra bit doubles the number of separate operations. We need at least five bits to get a reasonable variety. A few computers, however, like the DEC PDP-8 allow only three bits for this purpose.

Number of Separate Operations
vs
Number of Bits in Operation Code

Number of Bits	Number of Operations
3	8
4	16
5	32
6	64
7	128
8	256

Table 1.

The next requirement is the source (or sources) of the data. If either or both sources could be anywhere in memory, each instruction would have to contain one or two complete addresses. These addresses in typical small computers would be 16 bits long and would each occupy two bytes of program memory. The resulting instructions would be extremely long and slow to execute.

Limiting Addresses

Several methods can help solve the problem of long addresses. These methods include limiting the range of the addresses, fixing one or both of the addresses, and using addresses that are already present in the processor. Each of these techniques shortens individual instructions but limits the flexibility of the instruction set and increases the total number of instructions required for most programs.

We may limit the range of the addresses in several ways:

1) Divide the memory into smaller units called *pages*. The page number may be held in a page register. Then, only the address on the page must be included with the instruction. The DEC PDP-8 (and Intersil 6100) use this method. However, we will need special instructions and extra time to change pages. If a computer uses pages, the programmer must organize the program so that as few page changes as possible are necessary.

We should note that page zero is often special. Many computers (including those based on the Motorola 6800, MOS Technology 6502, and National PACE) allow the programmer to omit the page number on page zero so instructions which use addresses there can be very short. The idea is the same as dropping leading zeroes from numbers, e.g., we write 60 rather than 0060.

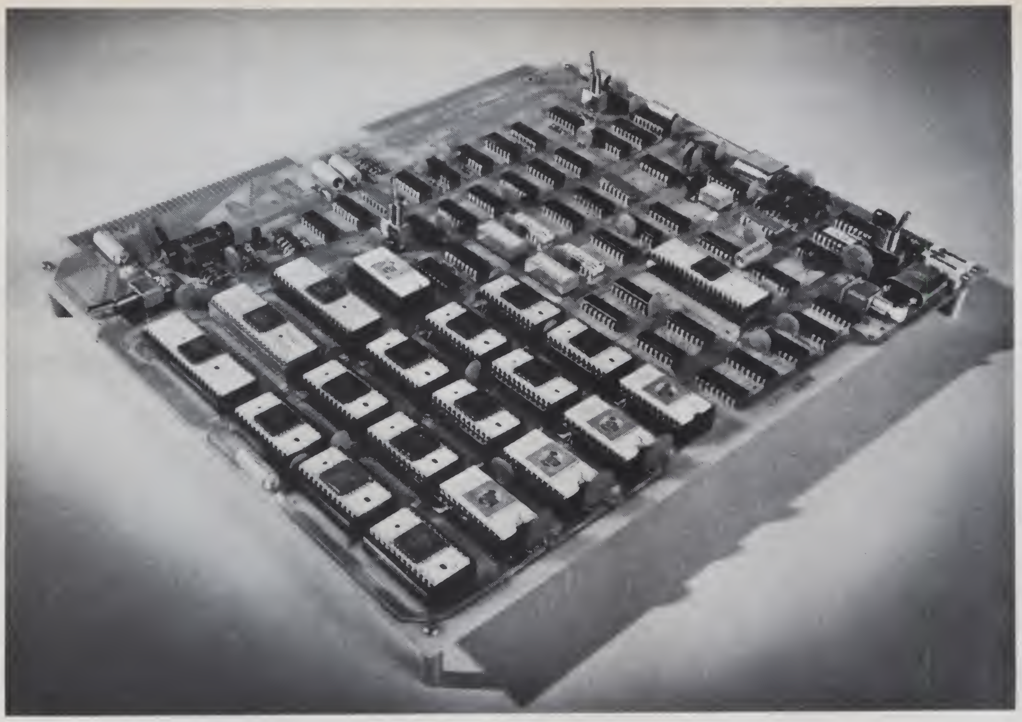
2) Require that the data be in registers. Now the addresses can be short since they must only distinguish among the registers. However, we will need extra instructions to load the registers from memory initially. We only get a real savings if we use the same data many times. This is the method used by the popular Intel 8080 microprocessor, the CPU in such computers as the Processor Technology SOL (see photo).

3) Specify the addresses as offsets from the index register or program counter. Here, again, the addresses can be shorter but we will need extra instructions to manipulate the index register and the CPU will need extra time to calculate the actual addresses. This is the method used by the Motorola 6800, the CPU in such computers as the American Micro-Systems EVK 300 (see photo).

Note how all these restrictions place more of the burden on the programmer. Two computers may have exactly the same instruction sets but be very different in the number of restrictions they place on addresses. The user will find the one with more *restrictions* to be slower and more difficult to program. Yet, few descriptions of computers include this information as an important point of comparison.

Finding Addresses

Frequently one or both of the source addresses is fixed



The American Micro-Systems EVK 300 Prototyping Board, a Motorola (AMI) 6800-based system.

as part of the architecture of the CPU. The most common method is for one operand always to come from an accumulator; the computer then works like a hand calculator. An instruction like ADD 100 means "add the contents of memory location 100 to the contents of the accumulator." Other fixed addresses may include a data register or a fixed memory location. Special instructions such as LOAD ACCUMULATOR start the process, i.e., to place data initially in the fixed address or register.

Addresses that are stored in registers may also be used as sources for data. We may place such addresses in address registers, stack pointers, or index registers. The Intel 8080, for example, uses registers H (*H*igh address) and L (*L*ow address) for this purpose. Using these registers allows the CPU to get data from memory without having an address specified in the instruction. Of course, the programmer will have to load these registers with some initial values, modify those values as needed, and keep track of them. The first two of these tasks require extra instructions. Note the convenience of the stack pointer since it not only contains a memory address but it is also automatically incremented or decremented with each use. We don't need an extra instruction to change the address when handling arrays of data.

The destination of the result is also an address which the CPU must determine. We can use any of the options mentioned for the source address. However, a simple technique that saves memory space is to make the destination the same as one of the sources. The CPU will then just place the result in the same register or memory location from which it obtained the original data. The problem is that the original data is then lost. We will need additional instructions (such as STORE ACCUMULATOR) if we want to save it. These extra transfers do not perform any real processing; they simply move data around so that the processing instructions operate correctly.

The next instruction address could be explicitly included in the instruction or could be derived by any of the methods mentioned. However, most CPUs actually use a program counter for this purpose. Each instruction cycle increments the program counter so that the next instruction is fetched from the next consecutive memory location. Programs must be stored sequentially, but this is a convenience to the programmer anyway. The only problem is that we do not want the CPU to keep on automatically incrementing the program counter indefinitely. Special instructions are necessary to stop or change the sequence of operations. JUMP, BRANCH, or CALL instructions change the value of the program counter and allow the CPU to execute instructions out of their sequential order. HALT or STOP instructions keep the CPU from proceeding at all.

One-address Instructions

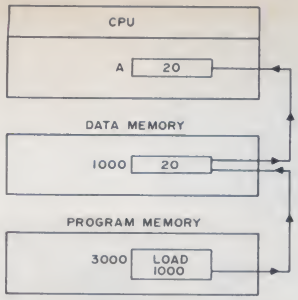
Since microprocessors have very short words, their instructions must be compact. Almost all processors use an accumulator as a source and the destination for most operations. Some processors have two or four accumulators (e.g., The Motorola 6800 or National PACE), but only one or two bits are needed to choose an accumulator for a particular instruction. The other source is therefore the only complete address which must be included. In this situation, an instruction like ADD 1000 actually means "add the contents of memory location 1000 to the contents of the accumulator and place the result back in the accumulator." Such *one-address instructions* are short, occupy only a few bytes of memory, and execute quickly. The problem is that a single instruction does not accomplish very much. We cannot, for example, have the CPU perform an ADD instruction unless we have previously placed something in the accumulator, nor can we use the accumulator again until we have stored the old result somewhere. Adding the contents of memory locations 40 and 41 and placing the result in 42 takes three instructions:

```
LOAD ACCUMULATOR   40
ADD                41
STORE ACCUMULATOR  42
```

Even the most elementary tasks require several instructions.

Each limitation on the instruction set reduces the throughput of the computer. Time spent loading and storing the contents of accumulators, address registers, index registers, and data registers is time taken away from actual work. In most programs written for small computers, more time goes to overhead than to processing. Most of the instructions move data around, place new values in the program counter, or change addresses.

Furthermore, such limited instruction sets make the programmer's task more difficult since more instructions are necessary and many of them have little to do with



The address included in the instruction tells the CPU where to get the data. Note that, even if the program is in PROM (and we cannot change the address), we can still change the data (in RAM).

Fig. 2. Instruction execution with Direct Addressing.

the object of the program. How many times, for example, have you forgotten to save a result, initialize a register, increment a counter, or jump past an unnecessary instruction? Such errors are often very difficult to find since the programmer does not think of all the details that the computer requires.

The computer needs a great deal of information to direct each cycle. If all of this information is in the instruction, the instruction will occupy a large amount of memory and execute very slowly. If some of the information is either fixed or in registers, then many short instructions will be necessary to accomplish simple tasks. Microprocessors, because of their short words, generally use simple one-address instructions which do not accomplish very much in a single cycle but must be combined into sequences to perform useful tasks.

Addressing Methods

Each time the CPU executes an instruction, it must get some data and store a result. Each instruction therefore must have one or more addresses which the CPU will use to fetch and store data. The way in which these addresses are specified determines whether a particular instruction can handle a single constant, one data item, or an entire array or table. The addressing methods available on a particular CPU allow the programmer to use simple instruction sets to perform complex and widely varied tasks. Each CPU has a set of addressing methods; the programmer must be aware not only of how they are implemented but also of when and why they are used.

Common addressing methods include the following:

- Direct
- Indirect
- Indexed
- Immediate or literal
- Relative
- Stack
- Register direct
- Register indirect

We will discuss each of these methods and pay particular attention to their uses and implementations in microprocessors with short data words. All arithmetic and logical instructions will be assumed to be one address, i.e., the instruction uses an accumulator as the source of one data item and the destination of the result.

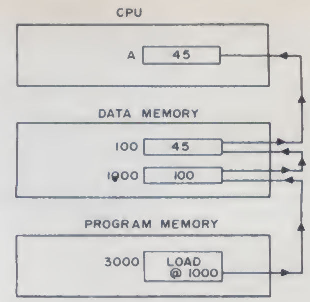
Direct and Indirect Addressing

Direct addressing (see Fig. 2) means that the address of the data is part of the instruction. E.g., ADD 135 means "add the contents of memory location 135 to the contents of the accumulator and place the result in the accumulator." We can and do change the contents of the data address; this location is in RAM. However, we may not be able to change the address itself since the program may be in a PROM. Direct addressing is useful for handling single data items such as the length of a list, the status of a set of switches or lights, or the average of a set of readings.

Indirect addressing (see Fig. 3) means that the address of the data address is part of the instruction. If that sounds confusing, you are right — it is! Indirect addressing is one of the most difficult concepts for newcomers to the computer field. The instruction ADD @ 135 (@ is a common symbol for indirect) means "add the contents of the address in memory location 135 to the accumulator." If we use ( ) to indicate "contents of," the instruction reults in (A) = (A) + ((135)) - note the double parentheses which means "the contents of the contents of." If, for example, memory location 135 contains 200, ADD @ 135 is the same as ADD 200. Note the flow of control in Fig. 3.

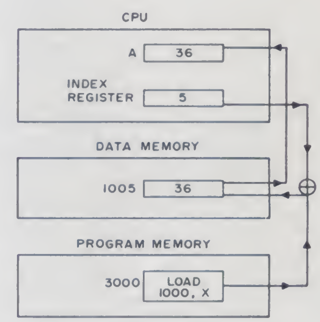
The question is what do we get from this confusion. The answer is that we can change not only the data at the data address, but also the data address itself (it, too, is in RAM rather than ROM)! Indirect addressing provides flexibility; the same program can handle data anywhere in memory — all we must do is change the indirect address. For example, an editing subprogram could process any line in a large text by using indirect addressing; the main program would direct the subprogram to a particular line by placing the starting address of the line in the indirect address. Indirect addressing can also be used to provide parameters to subroutines, handle lists and tables, and allow the user to specify data and addresses. Indirect addressing is difficult for programmers because it forces them to differentiate between data and addresses several times. However, the method is not difficult for the computer since it automatically makes the proper distinctions.

Indirect addressing is particularly inconvenient and confusing in 8-bit computers. Here, each address occupies two words of memory since addresses are usually 16-bits long. So we have a memory address which occupies two memory addresses and tells the CPU where to get the data. Fortunately, the computer does not get confused, although it does need extra time to fetch each 16-bit address.



The address included in the instruction tells the CPU where to get the address of the data. This method is slower than direct addressing but allows us to change both the data and its address even if the program is in PROM. The flow of control is confusing for the programmer but not for the computer.

Fig. 3. Instruction execution with Indirect Addressing.



Here the CPU adds the address in the instruction to the contents of the index register to find the source of the data. Changing the contents of the index register changes the address of the data.

Fig. 4. Instruction execution with Indexed Addressing.

Other Memory Addressing Methods

Indexed addressing (see Fig. 4) means that the address of the data is the sum of the address included with the instruction and the contents of the index register. The instruction ADD 135, X (X is a common symbol for indexed) means "add the contents of memory location 135 + the contents of the index register to the accumulator." If the index register contains 10, ADD 135, X is the same as ADD 145. We often call the address of the actual data

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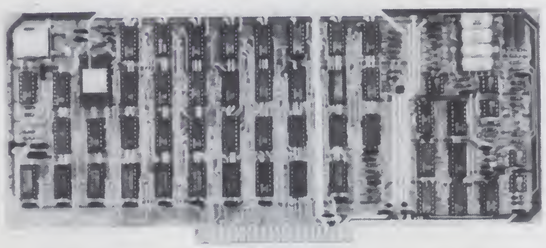
The Digital Group adds character(s).

64, to be exact.



The Digital Group's computer systems have a lot of character already. Just one quick look at any of our products in their unique custom cabinets confirms that. But we believe it never hurts to add a bit more.

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- 7x9 character matrix (effectively 7x12 due to character shifting)
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- 128 character ASCII
  - Upper case alpha
  - Lower case alpha with base line extenders (g, j, p, y)
  - Numbers and extended math symbols
  - Greek alphabet
- Software driven cursor—forward and backward
- Compatible with most microprocessors; Interfaces with 1 8-bit parallel output port
- Timebase may be driven with an external timebase (may be synchronized to TV camera, TV set, etc.)
- Readout timebase available at connector (can be used for graphic driver, etc.)
- White characters on black, and/or black on white; software selectable
- Plugs into standard dual 22-pin TVC connector on Digital Group Systems

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the *effective address*.

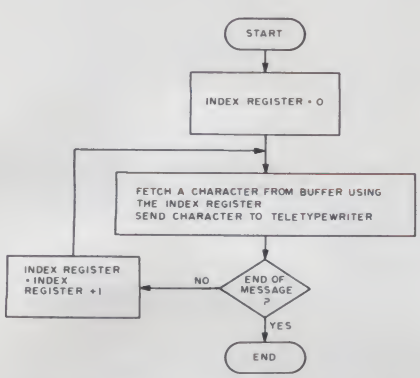
Indexed addressing is ideal for handling tables and arrays. Usually, the address included with the instruction is the starting address of the table or array. The index register then identifies a particular element. To get an element from an array, we must answer two questions: which array? and which element? Indexed addressing is easy to use since it provides this natural separation. If, for example, we want the tenth element of a table of squares, we place the starting address of the table in the instruction and ten in the index register. The Motorola 6800 microprocessor uses a somewhat different kind of indexing since it has a 16-bit index register and includes only an 8-bit offset with the instruction.

We may have two separate types of problems: one in which we want to handle each element in an array, as in calculating an average or writing a message on a teletypewriter; another in which we want to get one result from a table as in converting between different codes (e.g., decimal to seven-segment) or looking up telephone numbers. In the first type of problem (see the flowchart in Fig. 5) we start the index register at zero and increment it by 1 at the end of each iteration. A single sequence of instructions with indexed addressing will then handle an entire array of data. In the second type of problem (see Fig. 6), we place the data in the index register and get the corresponding table entry; a single sequence of instructions with indexed addressing will provide the correct answer for any data value.

Immediate or literal addressing (see Fig. 7) means that the data itself is part of the instruction. The instruction ADD #100 (# is a common symbol for immediate) means "add 100 to the contents of the accumulator." Immediate addressing is convenient for handling constants but offers no flexibility at all. The data is part of the program and cannot be changed. We may use immediate addressing to turn bits in a display output on or off, to search for characters from a keyboard, to compare data to a threshold, or to initialize counters and address registers.

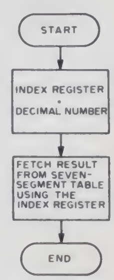
Relative addressing (see Fig. 8) means that the address is specified as an offset from the current value of the program counter. The instruction JUMP $+5 ($ is a common symbol for current program location) means "place a value five larger than the current value in the program counter." Relative addressing does not provide flexibility within a program since the effective address is a constant. However, it does allow an entire program to be moved since only relative positions are specified. Relative addressing makes a program *relocatable*, i.e., we can move the program to any area of memory that presently happens to be available, and use the same program on any system regardless of how its memory is arranged. Jump instructions often use relative addressing since most program jumps are rather short; the address with the instruction is therefore a short offset rather than a complete memory address.

Stack addressing (see Fig. 9) means that the data is the top element in a stack. Fig. 9 assumes the stack consists of a number of locations in data memory as in Intel 8080 or Motorola 6800 based computers. Usually the address of the top element is in a *stack pointer register*. Each time the CPU puts data in, it automatically changes the stack pointer so that it contains (or "points to") the address of the next available location. Similarly, each time the CPU removes data from the stack, it automatically moves the stack pointer back to the previous item. Thus we may keep placing data in the stack without destroying the old data and may get the data back in the opposite order from that in which it was entered. The stack operates like a cafeteria spring-loaded plate holder or like a cup



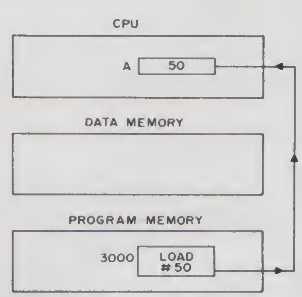
This program transfers a different character with each iteration until it reaches the end of the message.

Fig. 5. Flowchart of writing a message on a teletypewriter.



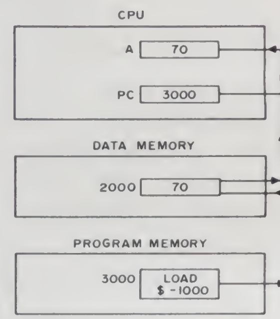
This program gets one result from an address in the table which is determined by the decimal number.

Fig. 6. Flowchart of Decimal to Seven Segment Conversion.



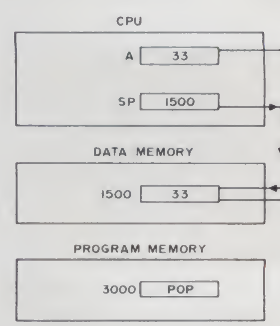
The CPU gets the data as part of the instruction in immediate addressing. The flow of control is simple (compare to Figs. 2, 3, and 4) but the data is fixed. Note that the instruction does not involve data memory at all.

Fig. 7. Instruction execution with Immediate Addressing.



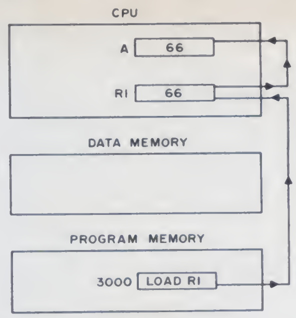
With relative addressing, the CPU adds the address in the instruction (which may be positive or negative) to the contents of the program counter. This allows us to move the program and the data. If, for example, we moved both the instruction and the data by 3000 locations (to 5000 and 6000 respectively), the data would still be the same distance from the instruction (1000 locations back).

Fig. 8. Instruction execution with Relative Addressing.



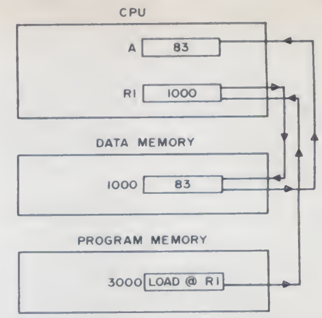
Stack addressing means that the data is in the stack. The CPU will fetch the data and update the stack pointer (by adding or subtracting one). We call fetching data from the stack a POP, storing data in the stack a PUSH. Note that the instruction really does not contain an address; it just indicates that the stack is to be used.

Fig. 9. Instruction execution with Stack Addressing.



Register direct addressing means that the data is in a register. The CPU only has to fetch the instruction from program memory; it does not use the data memory at all. However, a previous instruction must have placed some data in the register.

Fig. 10. Instruction execution with Register Direct Addressing.



Register indirect addressing means that the address of the data is in a register. The flow of control is just as complex as in indirect addressing (see Fig. 3), the advantage is that the instruction only has to contain a register address instead of a complete memory address. However, previous instructions must have placed a memory address in the register.

Fig. 11. Instruction execution with Register Indirect Addressing.

dispenser; it is a *last-in, first-out memory* (LIFO). Stack addressing is very flexible since the stack can be of any length, can be anywhere in memory, and provides its own order. However, the user will have to be careful to place the data in the stack and remove it properly and will have to keep the stack within its assigned limits in a particular system.

Register Addressing

Register direct addressing (see Fig. 10) is just like direct addressing except that the address is a register rather than a memory location. The advantages of register direct addressing are that the address can be very short (since it must only select one of the general-purpose registers) and that no memory accesses are necessary to get the data. Note how simple Fig. 10 is. ADD B, on a processor like the Intel 8080, means "add the contents of register B to the accumulator." Of course, before we use this instruction, we must place something in register B. Register direct addressing is therefore only advantageous when we can load the register once and then use the same data many times.

Register indirect addressing (see Fig. 11) is just like indirect addressing except that the data address is in a register rather than a memory location. On the Intel 8080, for example, ADD M means "add the contents of the memory location whose address is in registers H and L to the accumulator." Register indirect addressing has most of the same advantages and disadvantages as register direct addressing. As with indirect addressing, however, we can change the effective address by placing a new value in the indirect address or by incrementing or decrementing that address. Many Intel 8080 subroutines require an initial value in registers H and L; that starting address tells the subroutine where to get the data or where to begin working.

Register addresses are particularly convenient for processors with short words. The Intel 8080, Motorola 6800, MOS Technology 6502, and others all have 8-bit data words and 16-bit addresses. Therefore, complete memory addresses occupy two words of program memory and require two memory accesses. Even one word offsets take extra time and memory. Register direct and register indirect addressing solve the problem by using short register addresses that can fit into a single-word instruction.

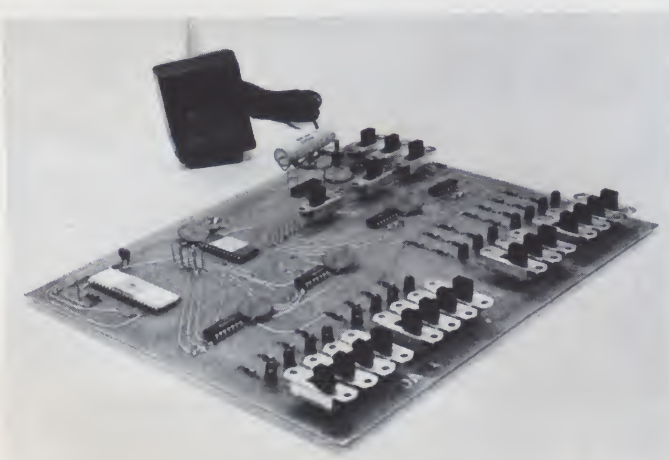
Combinations and Sets of Methods

Some processors allow combinations of methods. Popular combinations include indexed indirect addressing and indirect index addressing. The MOS Technology 6502 used in such computers as the OSI 300 (see photo), permits these methods. The computer, of course, has no trouble figuring out what to do, but the user may find that trying to understand such combinations of methods requires a drawing pad, a lot of concentration, and, perhaps, some aspirin.

No single addressing method solves all programming tasks. We generally use several methods to handle different situations within each program. Direct and register direct addressing are convenient for single data items. Indirect, indexed, stack, and register indirect addressing are convenient for arrays, lists, or tables. Immediate addressing is useful for constants while relative addressing makes programs shorter and easier to move.

Microprocessors offer a more limited choice of addressing methods than do larger CPUs. Still, the Intel 8080 has direct, immediate, stack, register direct, and register indirect addressing; the Motorola 6800 has direct, immediate, indexed, relative, and stack addressing. The Zilog Z-80 offers all the addressing methods we have mentioned.

Most computers have rather simple instruction sets. Different addressing methods add power and flexibility to the instructions and allow the computer to handle a tremendous variety of tasks. By selecting addressing methods properly, the programmer can make the computer collect data, process arrays or lists, use tables, and respond to commands. The limited sets of addressing methods available on standard microprocessors make many tasks awkward; the more extensive sets available on new devices like the Zilog Z-80 give the programmer far greater capabilities. ■



The Ohio Scientific Instruments Model 300 Computer Trainer, a MOS Technology 6502-based system.

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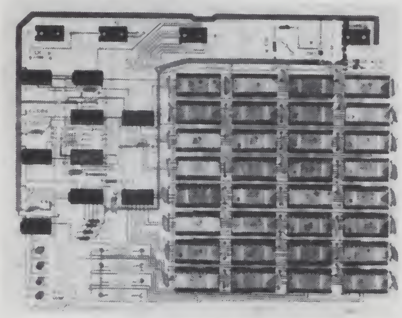

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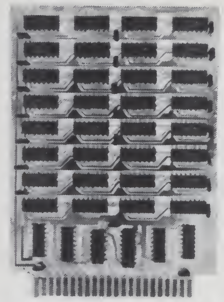

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O1

Introducing the Disassembler

Phil Hughes
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An unassembler (or disassembler) is a program which takes machine language and converts it into what appears to be assembly language. The input to the disassembler is generally a program which is contained in computer memory and the output is generally printed output which looks much like an assembly language listing.

The one thing which a disassembler cannot do is generate the meaningful labels and comments which appeared in the original source program, but it can be very helpful as a debugging aid. For example, if you have purchased a new printer and want to interface it to the I/O routines of your computer system's BASIC interpreter you may have to modify those routines. Even though you do not have source code for those I/O routines, you can disassemble them and have something much easier to work with than an octal or hexadecimal memory dump. If you have written a program in machine code, you can also use the disassembler to document your program.

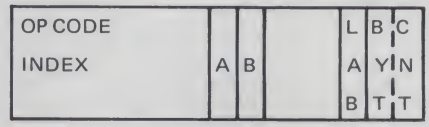
The Design

The disassembler presented here was designed to operate on a SWTPC 6800 system. The design should work with any computer and the program presented can be easily modified to work with any 6800 based system. Also, if Motorola comes out with the new 680X superchip to replace the 6800, the unassembler should be easy to update as the decoding is performed by the use of tables. The only portion of the decoding operation which is hard coded (instead of using tables) is the address mode (relative, indexed, etc.) of the instructions. If you desired to make the design even more flexible, this information could also be added to the tables.

In order to perform the disassembly function, two tables are used. Table 1, called the op code table, has an entry for every possible operation code (0 through 255). Each table entry is 2 bytes long and contains the following information:

1. An index into the mnemonic table.
2. Indicators for the accumulator used (if any).
3. The length of the instruction in bytes.
4. A flag to indicate if this instruction is an unconditional transfer of control (JMP, RTS, etc.).

An entry in this table is illustrated in Fig. 1.



Op code index	— Pointer into the Mnemonic table.
A	— Indicates A register used if set.
B	— Indicates B register used if set.
LAB	— Indicates unconditional transfer instruction.
BYT CNT	— Length of instruction in bytes.

Fig. 1. Layout of an op code Table Entry.

The second table, called the mnemonic table, contains all the valid assembler mnemonics for the possible machine instructions. Note that pseudo operations such as EQU and FCC do not appear in the table. These do not generate instructions (although FCC does use memory space) and therefore could never be generated through the disassembly process. An entry in this table is illustrated in Fig. 2.

Table 1 shows the assumptions that were made concerning the address mode of the instructions. The exception (we always have an exception) is that op code 8D is the BSR instruction and is therefore relative, not immediate as would be expected.

The Program

The program flow is straightforward. Once the user sets location A002 and A003 to the address of the program to be disassembled and initiates execution of the unassembler the following takes place.

The first byte of data (program to be disassembled) is picked up, multiplied by 2 and used to compute the address of the appropriate op code table entry. The data address (from A002 and A003) is converted to a character string and put into the output line buffer.

Next, using the op code table entry the mnemonic is picked up from the mnemonic table and transferred to the output line buffer. Then the address field is converted and placed in the print line, using the A and B fields and the length field from the op code table. If the address mode is relative, the offset is added to the address of the next instruction and saved in the print line as the absolute address. The print routine is then called to print the data contained in the output buffer.

Finally, if the op code table entry had the lab bit set indicating that we have just processed an unconditional transfer instruction, a period is placed in position 7 of the print buffer so that the next line printed will have a flag indicating that it should have a label. This is because the only path to this instruction would be through a transfer of control instruction such as BRA.

If decoding the op code does not yield a valid mnemonic (mnemonic index of 0) three asterisks are printed in the operation field followed by the op code byte displayed in hexadecimal.

Using the Unassembler on a SWTPC 6800

If you have a SWTPC 6800 system configured with the AC-30 cassette interface on I/O port 1 and PR-40 printer on I/O port 7 and at least 8K bytes of memory then the following procedure would load the unassembler and cause it to unassemble itself:

First 4 bits of op code (hex)	Address Mode
1,3,4 or 5	Inherent
2	Relative
6,A or E	Indexed
7,B or F	Extended
8,C	Immediate
9,D	Direct

Table 1. Address Mode Decoding.

1. Load the object tape using the MIKBUG L key-in.
2. Using the MIKBUG M key-in set location A002 to the address of the program to be disassembled. In this case it is 1B36, the first instruction of the disassembler.
3. Enter G to start program execution.
4. When the disassembler has decoded enough push reset to stop execution.

Typing G will cause the disassembler to resume operation at the next location. Also, by changing the contents of A002 and typing G the disassembler will resume operation at the new starting address.

Modifications

With only minor modifications the disassembler can be changed to operate with almost any 6800 based system. To change it to print on the control interface it is only necessary to delete the PR-40 handler code and insert the following:

```
BINIT    RTS
PDATA1 EQU $E07E
```

For anyone who does not use MIKBUG it is only necessary to replace the code at BINIT with the necessary printer initialization code and the code at PDATA1 with code which will print the ASCII string pointed to by the index register. Note that the end of string is signified by an ASCII EOT (hex 04) character.

If you have any occasional problems with strange looking output it is most likely an error in the tables. Check carefully, one missing byte can skew all the other data and generate very strange results. ■

```
1B36          LDS     #1B08
1B39          JSR     1C97
1B3C          LDX     A002
1B3F          LDA A   00,X
1B41          STA A   1B0A
1B44          ASL A
1B45          LDX     #1D93
1B48          STX     1B0B
1B4B          BCC     1B50
1B4D          INC     1B0B
1B50          LDA B   1B0C
1B53          ABA
1B54          STA A   1B0C
1B57          BCC     1B5C
1B59          INC     1B0B
1B5C          LDX     #1B0E
1B5F          LDA A   A002
1B62          JSR     1C7D
1B65          LDA A   A003
1B68          JSR     1C7D
1B6B          LDX     1B0B
1B6E          LDA A   00,X
1B70          STA A   1B0B
1B73          LDA B   01,X
1B75          STA B   1B0D
1B78          AND B   #03
1B7A          LDX     A002
1B7D          LDA A   01,X
1B7F          STA A   1B08
1B82          LDA A   02,X
1B84          STA A   1B09
1B87          INX
1B88          DEC B
1B89          BNE     1B87
1B8B          STX     A002
1B8E          LDA A   1B0B
1B91          TAB
1B92          LDX     #1CB8
1B95          STX     1B0B
1B98          ASL A
1B99          BCC     1B9F
1B9B          INC     1B0B
1B9E          CLC
1B9F          ABA
1BA0          BCC     1BA5
1BA2          INC     1B0B
1BA5          CLC
1BA6          ADD A   1B0C
1BA9          BCC     1BAE
1BAB          INC     1B0B
1BAE          STA A   1B0C
1BB1          LDX     1B0B
1BB4          LDA A   00,X
1BB6          STA A   1B1F
1BB9          LDA A   01,X
1BBB          STA A   1B20
1BBE          LDA A   02,X
1BC0          STA A   1B21
1BC3          LDA B   #20
1BC5          STA B   1B22
1BC8          LDA A   1B0D
1BCB          BIT A   #C0
1BCD          BEQ     1BD7
1BCF          BPL     1BD5
1BD1          LDA B   #41
```

Example A. Sample Program Execution (disassembly of portion of Disassembler Program).

3 ASCII character mnemonic

Fig. 2. Layout of Mnemonic Table Entry.

Program A. Listings for Disassembler Program.

```
PAGE  001   UNASS

                        NAM     UNASS
                        OPT     O
                        OPT     S
                        OPT     NOP
                        OPT     G
                 * $A002 CONTAINS START
                 * ADDRESS OF CODE TO
                 * DISASSEMBLE
                 *
                 * EQU'S
                 * PR-40 PIA ADDRESS
        801C     PRPIA  EQU     $801C
                 *
1B00                    ORG     $1B00
                 * STACK SAVE
1B00 0008               RMB     8
     1B08        SSAV   EQU     *
1B08 0002        OPER   RMB     2          OPER
1B0A 0001        SAVA   RMB     1
1B0B 0002        TMP    RMB     2
1B0D 0001        BAR    RMB     1
1B0E 20          LIN    FCC     40,
1B0F 20
1B10 20
1B11 20
1B12 20
1B13 20
1B14 20
1B15 20
1B16 20
1B17 20
1B18 20
1B19 20
1B1A 20
1B1B 20
1B1C 20
1B1D 20
1B1E 20
1B1F 20
1B20 20
1B21 20
1B22 20
1B23 20
1B24 20
1B25 20
1B26 20
1B27 20
1B28 20
1B29 20
1B2A 20
1B2B 20
1B2C 20
1B2D 20
1B2E 20
1B2F 20
1B30 20
1B31 20
1B32 20
1B33 20
1B34 20
1B35 20
                 *
     1B36        UNAS   EQU     *
1B36 8E 1B08            LDS     #SSAV
1B39 BD 1C97            JSR     BINIT
     1B3C        AGN    EQU     *
                 * START ADDRESS
1B3C FE A002            LDX     $A002
1B3F A6 00              LDA A   0,X
1B41 B7 1B0A            STA A   SAVA

1B44 48                 ASL A
```

```
1B45 CE 1D93          LDX    #OPS
1B48 FF 1B0B          STX    TMP
1B4B 24 03            BCC    NOC
1B4D 7C 1B0B          INC    TMP
1B50 F6 1B0C NOC      LDA B  TMP+1
1B53 1B               ABA

1B54 B7 1B0C          STA A  TMP+1
1B57 24 03            BCC    NOD
1B59 7C 1B0B          INC    TMP
                 * ADDRESS
     1B5C        NOD  EQU    *
1B5C CE 1B0E          LDX    #LIN
1B5F B6 A002          LDA A  $A002
1B62 BD 1C7D          JSR    CBH
1B65 B6 A003          LDA A  $A003
1B68 BD 1C7D          JSR    CBH
                 * OPS INDEX
1B6B FE 1B0B          LDX    TMP
1B6E A6 00            LDA A  0,X
1B70 B7 1B0B          STA A  TMP
                 * REG/LENGTH
1B73 E6 01            LDA B  1,X
1B75 F7 1B0D          STA B  BAR
1B78 C4 03            AND B  #03
1B7A FE A002          LDX    $A002
                 * SAVE POSSIBLE OPERANDS
1B7D A6 01            LDA A  1,X
1B7F B7 1B08          STA A  OPER
1B82 A6 02            LDA A  2,X
1B84 B7 1B09          STA A  OPER+1
                 * UPDATE INST POINTER
1B87 08          MORE INX

1B88 5A               DEC B
1B89 26 FC            BNE    MORE
1B8B FF A002          STX    $A002
1B8E B6 1B0B          LDA A  TMP
1B91 16               TAB

1B92 CE 1CB8          LDX    #MNET
1B95 FF 1B0B          STX    TMP
1B98 48               ASL A

1B99 24 04            BCC    NOE
1B9B 7C 1B0B          INC    TMP
1B9E 0C               CLC

1B9F 1B          NOE  ABA

1BA0 24 03            BCC    NOF
1BA2 7C 1B0B          INC    TMP
1BA5 0C          NOF  CLC
1BA6 BB 1B0C          ADD A  TMP+1
1BA9 24 03            BCC    NOG
1BAB 7C 1B0B          INC    TMP
1BAE B7 1B0C NOG      STA A  TMP+1
1BB1 FE 1B0B          LDX    TMP
1BB4 A6 00            LDA A  0,X
1BB6 B7 1B1F          STA A  LIN+17
1BB9 A6 01            LDA A  1,X
1BBB B7 1B20          STA A  LIN+18
1BBE A6 02            LDA A  2,X
1BC0 B7 1B21          STA A  LIN+19
1BC3 C6 20            LDA B  #'

1BC5 F7 1B22          STA B  LIN+20
1BC8 B6 1B0D          LDA A  BAR
1BCB 85 C0            BIT A  #$C0
1BCD 27 08            BEQ    SREG
1BCF 2A 04            BPL    BREG
1BD1 C6 41            LDA B  #'A
1BD3 20 02            BRA    SREG
1BD5 C6 42   BREG     LDA B  #'B
1BD7 F7 1B23 SREG     STA B  LIN+21
```

```
1BDA CE 1B26          LDX    #LIN+24
1BDD B6 1B1F          LDA A  LIN+17
1BE0 81 2A            CMP A  #'*
1BE2 26 08            BNE    NOTBAD
1BE4 B6 1B0A          LDA A  SAVA
1BE7 BD 1C7D          JSR    CBH
1BEA 20 40            BRA    NOOPR
1BEC B6 1B0D NOTBAD   LDA A  BAR
1BEF 85 02            BIT A  #$02
1BF1 27 39            BEQ    NOOPR
1BF3 B6 1B0A          LDA A  SAVA
1BF6 81 8D            CMP A  #$8D
1BF8 27 12            BEQ    NOTIMM
1BFA 84 F0            AND A  #$F0
1BFC B7 1B0A          STA A  SAVA
1BFF 81 80            CMP A  #$80
1C01 27 04            BEQ    IMM
1C03 81 C0            CMP A  #$C0
1C05 26 05            BNE    NOTIMM
                 * FLAG IMM ADDRESS
1C07 86 23   IMM      LDA A  #'#
1C09 A7 00            STA A  0,X
1C0B 08               INX

     1C0C    NOTIMM   EQU    *
             *  CHECK FOR REL ADDRESS
1C0C B6 1B0A          LDA A  SAVA      GET
1C0F 81 8D            CMP A  #$8D      BRA?
1C11 27 55            BEQ    REL       YES
1C13 84 F0            AND A  #$F0
1C15 81 20            CMP A  #$20      OTHE
1C17 27 4F            BEQ    REL       YES
1C19 B6 1B08          LDA A  OPER
1C1C BD 1C7D          JSR    CBH
1C1F B6 1B0D          LDA A  BAR
1C22 85 01            BIT A  #$1
1C24 27 06            BEQ    NOOPR
1C26 B6 1B09          LDA A  OPER+1
1C29 BD 1C7D          JSR    CBH
     1C2C    NOOPR    EQU    *
1C2C B6 1B0A          LDA A  SAVA
1C2F 81 60            CMP A  #$60
1C31 27 08            BEQ    INDXD
1C33 81 A0            CMP A  #$A0
1C35 27 04            BEQ    INDXD
1C37 81 E0            CMP A  #$E0
1C39 26 0A            BNE    NOTX
             * PUT ',X' IN LINE
1C3B 86 2C   INDXD    LDA A  #',
1C3D A7 00            STA A  0,X
1C3F 08               INX

1C40 86 58            LDA A  #'X
1C42 A7 00            STA A  0,X
1C44 08               INX

     1C45    NOTX     EQU    *
             * PRINT LINE
1C45 86 0D            LDA A  #$0D
1C47 A7 00            STA A  0,X
1C49 86 0A            LDA A  #$0A
1C4B A7 01            STA A  1,X
1C4D 86 04            LDA A  #$04
1C4F A7 02            STA A  2,X
1C51 CE 1B0E          LDX    #LIN
1C54 BD 1CA5          JSR    PDATA1
             * IF THE LAST INST WAS
             * UNCONDITIONAL XFER THEN
             * FLAG LABEL FIELD ON THE
             * NEXT LINE
1C57 86 20            LDA A  #'

             * CHECK LAB BIT
1C59 F6 1B0D          LDA B  BAR
1C5C C4 10            AND B  #$10
1C5E 27 02            BEQ    NOLAB
1C60 86 2E            LDA A  #'.
1C62 B7 1B14 NOLAB    STA A  LIN+6
```

```
1C65 7E 1B3C          JMP    AGN
                * COMPUTE RELATIVE ADDR
1C68 4F         REL    CLR A
1C69 F6 1B08           LDA B  OPER
1C6C 2A 01             BPL    NNREL
1C6E 4A                DEC A

1C6F 0C         NNREL  CLC

1C70 FB A003           ADD B  $A003    L.O.
1C73 B9 A002           ADC A  $A002    H.O.
1C76 8D 05             BSR    CBH      CONV
1C78 17                TBA

1C79 8D 02             BSR    CBH      CONV
1C7B 20 C8             BRA    NOTX
     1C7D       CBH    EQU    *
                *
                *  CONVERT BINARY NUMBER
                * IN A-REG TO 2 HEX
                *   CHRS AND SAV IN
                *  ADDR IN X-REG
                * INC X-REG
1C7D 36                PSH A
1C7E 8D 06             BSR    CBHLH
1C80 32                PUL A

1C81 08                INX

1C82 8D 06             BSR    CBHRH
1C84 08                INX

1C85 39                RTS

1C86 44         CBHLH  LSR A

1C87 44                LSR A

1C88 44                LSR A

1C89 44                LSR A

1C8A 84 0F      CBHRH  AND A  #$F
1C8C 8B 30             ADD A  #$30
1C8E 81 39             CMP A  #$39
1C90 23 02             BLS    CBHOK
1C92 8B 07             ADD A  #$7
1C94 A7 00      CBHOK  STA A  0,X
1C96 39                RTS

                ************
                * PR-40 HANDLER
                *
                * REPLACE THIS CODE
                * WITH :
                *  BINIT  RTS
                *  PDATA1 EQU $E07E
                * TO OUTPUT TO CONTROL INTERFACE
                *
                *
                * PR-40 INITIALIZATION
1C97 86 FF      BINIT  LDA A  #$FF
1C99 B7 801C           STA A  PRPIA
1C9C 86 2E             LDA A  #$2E
1C9E B7 801D           STA A  PRPIA+1
1CA1 39                RTS

                *
                *
     1CA2       PDATA2 EQU    *
1CA2 8D 08             BSR    OUTCH
1CA4 08                INX

                * PRINT LINE ON PR-40
     1CA5       PDATA1 EQU    *
1CA5 A6 00             LDA A  0,X
1CA7 81 04             CMP A  #4
1CA9 26 F7             BNE    PDATA2
1CAB 39                RTS

     1CAC       OUTCH  EQU    *
1CAC B7 801C           STA A  PRPIA
1CAF B6 801C           LDA A  PRPIA
1CB2 7D 801D    PLUP   TST    PRPIA+1
1CB5 2A FB             BPL    PLUP
1CB7 39                RTS

                *
                * END OF PR-40 HANDLER
                ***********************
                *
1CB8 2A         MNET   FCC    /***/
1CB9 2A
1CBA 2A
1CBB 4E                FCC    /NOP/
1CBC 4F
1CBD 50
1CBE 54                FCC    /TAP/
1CBF 41
1CC0 50
1CC1 54                FCC    /TPA/
1CC2 50
1CC3 41
1CC4 49                FCC    /INX/
1CC5 4E
1CC6 58
1CC7 44                FCC    /DEX/
1CC8 45
1CC9 58
1CCA 43                FCC    /CLV/
1CCB 4C
1CCC 56
1CCD 53                FCC    /SEV/
1CCE 45
1CCF 56
1CD0 43                FCC    /CLC/
1CD1 4C
1CD2 43
1CD3 53                FCC    /SEC/
1CD4 45
1CD5 43
1CD6 43                FCC    /CLI/
1CD7 4C
1CD8 49
1CD9 53                FCC    /SEI/
1CDA 45
1CDB 49
1CDC 53                FCC    /SBA/
1CDD 42
1CDE 41
1CDF 43                FCC    /CBA/
1CE0 42
1CE1 41
1CE2 54                FCC    /TAB/
1CE3 41
1CE4 42
1CE5 54                FCC    /TBA/
1CE6 42
1CE7 41
                 *  $10
1CE8 44                FCC    /DAA/
1CE9 41
1CEA 41
1CEB 41                FCC    /ABA/
1CEC 42
1CED 41
1CEE 42                FCC    /BRA/
1CEF 52
1CF0 41
1CF1 42                FCC    /BHI/
1CF2 48
1CF3 49
1CF4 42                FCC    /BLS/
1CF5 4C
1CF6 53
1CF7 42                FCC    /BCC/
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```
1CF8 43
1CF9 43
1CFA 42          FCC    /BCS/
1CFB 43
1CFC 53
1CFD 42          FCC    /BNE/
1CFE 4E
1CFF 45
1D00 42          FCC    /BEQ/
1D01 45
1D02 51
1D03 42          FCC    /BVC/
1D04 56
1D05 43
1D06 42          FCC    /BVS/
1D07 56
1D08 53
1D09 42          FCC    /BPL/
1D0A 50
1D0B 4C
1D0C 42          FCC    /BMI/
1D0D 4D
1D0E 49
1D0F 42          FCC    /BGE/
1D10 47
1D11 45
1D12 42          FCC    /BLT/
1D13 4C
1D14 54
1D15 42          FCC    /BGT/
1D16 47
1D17 54
          *  $20
1D18 42          FCC    /BLE/
1D19 4C
1D1A 45
1D1B 54          FCC    /TSX/
1D1C 53
1D1D 58
1D1E 49          FCC    /INS/
1D1F 4E
1D20 53
1D21 50          FCC    /PUL/
1D22 55
1D23 4C
1D24 44          FCC    /DES/
1D25 45
1D26 53
1D27 54          FCC    /TXS/
1D28 58
1D29 53
1D2A 50          FCC    /PSH/
1D2B 53
1D2C 48
1D2D 52          FCC    /RTS/
1D2E 54
1D2F 53
1D30 52          FCC    /RTI/
1D31 54
1D32 49
1D33 57          FCC    /WAI/
1D34 41
1D35 49
1D36 53          FCC    /SWI/
1D37 57
1D38 49
1D39 4E          FCC    /NEG/
1D3A 45
1D3B 47
1D3C 43          FCC    /COM/
1D3D 4F
1D3E 4D
1D3F 4C          FCC    /LSR/
1D40 53
1D41 52
1D42 52          FCC    /ROR/
1D43 4F
1D44 52
1D45 41          FCC    /ASR/
1D46 53
1D47 52
          *  $30
1D48 41          FCC    /ASL/
1D49 53
1D4A 4C
1D4B 52          FCC    /ROL/
1D4C 4F
1D4D 4C
1D4E 44          FCC    /DEC/
1D4F 45
1D50 43
1D51 49          FCC    /INC/
1D52 4E
1D53 43
1D54 54          FCC    /TST/
1D55 53
1D56 54
1D57 43          FCC    /CLR/
1D58 4C
1D59 52
1D5A 4A          FCC    /JMP/
1D5B 4D
1D5C 50
1D5D 53          FCC    /SUB/
1D5E 55
1D5F 42
1D60 43          FCC    /CMP/
1D61 4D
1D62 50
1D63 53          FCC    /SBC/
1D64 42
1D65 43
1D66 41          FCC    /AND/
1D67 4E
1D68 44
1D69 42          FCC    /BIT/
1D6A 49
1D6B 54
1D6C 4C          FCC    /LDA/
1D6D 44
1D6E 41
1D6F 45          FCC    /EOR/
1D70 4F
1D71 52
1D72 41          FCC    /ADC/
1D73 44
1D74 43
1D75 4F          FCC    /ORA/
1D76 52
1D77 41
1D78 41          FCC    /ADD/
1D79 44
1D7A 44
1D7B 43          FCC    /CPX/
1D7C 50
1D7D 58
1D7E 42          FCC    /BSR/
1D7F 53
1D80 52
1D81 4C          FCC    /LDS/
1D82 44
1D83 53
1D84 53          FCC    /STA/
1D85 54
1D86 41
1D87 53          FCC    /STS/
1D88 54
1D89 53
1D8A 4A          FCC    /JSR/
1D8B 53
1D8C 52
1D8D 4C          FCC    /LDX/
1D8E 44
1D8F 58
1D90 53          FCC    /STX/
1D91 54
1D92 58
                 * OPCODES
                 * COL 1
1D93 0001        OPS    FDB    $0001
1D95 0101               FDB    $0101
1D97 0001               FDB    $0001
1D99 0001               FDB    $0001
1D9B 0001               FDB    $0001
1D9D 0001               FDB    $0001
1D9F 0201               FDB    $0201
1DA1 0301               FDB    $0301
1DA3 0401               FDB    $0401
1DA5 0501               FDB    $0501
1DA7 0601               FDB    $0601
1DA9 0701               FDB    $0701
1DAB 0801               FDB    $0801
1DAD 0901               FDB    $0901
1DAF 0A01               FDB    $0A01
1DB1 0B01               FDB    $0B01
1DB3 0C01               FDB    $0C01
1DB5 0D01               FDB    $0D01
1DB7 0001               FDB    $0001
1DB9 0001               FDB    $0001
1DBB 0001               FDB    $0001
1DBD 0001               FDB    $0001
1DBF 0E01               FDB    $0E01
1DC1 0F01               FDB    $0F01
1DC3 0001               FDB    $0001
1DC5 1001               FDB    $1001
1DC7 0001               FDB    $0001
1DC9 1101               FDB    $1101
1DCB 0001               FDB    $0001
1DCD 0001               FDB    $0001
1DCF 0001               FDB    $0001
1DD1 0001               FDB    $0001
1DD3 1212               FDB    $1212
1DD5 0001               FDB    $0001
1DD7 1302               FDB    $1302
1DD9 1402               FDB    $1402
1DDB 1502               FDB    $1502
1DDD 1602               FDB    $1602
1DDF 1702               FDB    $1702
1DE1 1802               FDB    $1802
                 * COL 2
1DE3 1902               FDB    $1902
1DE5 1A02               FDB    $1A02
1DE7 1B02               FDB    $1B02
1DE9 1C02               FDB    $1C02
1DEB 1D02               FDB    $1D02
1DED 1E02               FDB    $1E02
1DEF 1F02               FDB    $1F02
1DF1 2002               FDB    $2002
1DF3 2101               FDB    $2101
1DF5 2201               FDB    $2201
1DF7 2301               FDB    $2301
1DF9 2341               FDB    $2341
1DFB 2401               FDB    $2401
1DFD 2501               FDB    $2501
1DFF 2681               FDB    $2681
1E01 2641               FDB    $2641
1E03 0001               FDB    $0001
1E05 2711               FDB    $2711
1E07 0001               FDB    $0001
1E09 2811               FDB    $2811
1E0B 0001               FDB    $0001
1E0D 0001               FDB    $0001
1E0F 2901               FDB    $2901
1E11 2A01               FDB    $2A01
1E13 2B01               FDB    $2B01
1E15 0001               FDB    $0001
1E17 0001               FDB    $0001
1E19 2C81               FDB    $2C81
1E1B 2D81               FDB    $2D81
1E1D 0001               FDB    $0001
1E1F 2E81               FDB    $2E81
1E21 2F81               FDB    $2F81
1E23 3081               FDB    $3081
1E25 3181               FDB    $3181
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1E27 3281          FDB   $3281
1E29 0001          FDB   $0001
1E2B 3381          FDB   $3381
1E2D 3481          FDB   $3481
1E2F 0001          FDB   $0001
1E31 3581          FDB   $3581
          * COL 3
1E33 2B41          FDB   $2B41
1E35 0001          FDB   $0001
1E37 0001          FDB   $0001
1E39 2C41          FDB   $2C41
1E3B 2D41          FDB   $2D41
1E3D 0001          FDB   $0001
1E3F 2E41          FDB   $2E41
1E41 2F41          FDB   $2F41
1E43 3041          FDB   $3041
1E45 3141          FDB   $3141
1E47 3241          FDB   $3241
1E49 0001          FDB   $0001
1E4B 3341          FDB   $3341
1E4D 3441          FDB   $3441
1E4F 0001          FDB   $0001
1E51 3541          FDB   $3541
1E53 2B02          FDB   $2B02
1E55 0001          FDB   $0001
1E57 0001          FDB   $0001
1E59 2C02          FDB   $2C02
1E5B 2D02          FDB   $2D02
1E5D 0001          FDB   $0001
1E5F 2E02          FDB   $2E02
1E61 2F02          FDB   $2F02
1E63 3002          FDB   $3002
1E65 3102          FDB   $3102
1E67 3202          FDB   $3202
1E69 0001          FDB   $0001
1E6B 3302          FDB   $3302
1E6D 3402          FDB   $3402
1E6F 3612          FDB   $3612
1E71 3502          FDB   $3502
1E73 2B03          FDB   $2B03
1E75 0001          FDB   $0001
1E77 0001          FDB   $0001
1E79 2C03          FDB   $2C03
1E7B 2D03          FDB   $2D03
1E7D 0001          FDB   $0001
1E7F 2E03          FDB   $2E03
1E81 2F03          FDB   $2F03
          * COL 4
1E83 3003          FDB   $3003
1E85 3103          FDB   $3103
1E87 3203          FDB   $3203
1E89 0001          FDB   $0001
1E8B 3303          FDB   $3303
1E8D 3403          FDB   $3403
1E8F 3613          FDB   $3613
1E91 3503          FDB   $3503
1E93 3782          FDB   $3782
1E95 3882          FDB   $3882
1E97 3982          FDB   $3982
1E99 0001          FDB   $0001
1E9B 3A82          FDB   $3A82
1E9D 3B82          FDB   $3B82
1E9F 3C82          FDB   $3C82
1EA1 0001          FDB   $0001
1EA3 3D82          FDB   $3D82
1EA5 3E82          FDB   $3E82
1EA7 3F82          FDB   $3F82
1EA9 4082          FDB   $4082
1EAB 4103          FDB   $4103
1EAD 4202          FDB   $4202
1EAF 4303          FDB   $4303
1EB1 0001          FDB   $0001
1EB3 3782          FDB   $3782
1EB5 3882          FDB   $3882
1EB7 3982          FDB   $3982
1EB9 0001          FDB   $0001
1EBB 3A82          FDB   $3A82
1EBD 3B82          FDB   $3B82
1EBF 3C82          FDB   $3C82
1EC1 4482          FDB   $4482
1EC3 3D82          FDB   $3D82
1EC5 3E82          FDB   $3E82
1EC7 3F82          FDB   $3F82
1EC9 4082          FDB   $4082
1ECB 4102          FDB   $4102
1ECD 0001          FDB   $0001
1ECF 4302          FDB   $4302
1ED1 4502          FDB   $4502
          * COL 5
1ED3 3782          FDB   $3782
1ED5 3882          FDB   $3882
1ED7 3982          FDB   $3982
1ED9 0001          FDB   $0001
1EDB 3A82          FDB   $3A82
1EDD 3B82          FDB   $3B82
1EDF 3C82          FDB   $3C82
1EE1 4482          FDB   $4482
1EE3 3D82          FDB   $3D82
1EE5 3E82          FDB   $3E82
1EE7 3F82          FDB   $3F82
1EE9 4082          FDB   $4082
1EEB 4102          FDB   $4102
1EED 4602          FDB   $4602
1EEF 4302          FDB   $4302
1EF1 4502          FDB   $4502
1EF3 3783          FDB   $3783
1EF5 3883          FDB   $3883
1EF7 3983          FDB   $3983
1EF9 0001          FDB   $0001
1EFB 3A83          FDB   $3A83
1EFD 3B83          FDB   $3B83
1EFF 3C83          FDB   $3C83
1F01 4483          FDB   $4483
1F03 3D83          FDB   $3D83
1F05 3E83          FDB   $3E83
1F07 3F83          FDB   $3F83
1F09 4083          FDB   $4083
1F0B 4103          FDB   $4103
1F0D 4603          FDB   $4603
1F0F 4303          FDB   $4303
1F11 4503          FDB   $4503
1F13 3742          FDB   $3742
1F15 3842          FDB   $3842
1F17 3942          FDB   $3942
1F19 0001          FDB   $0001
1F1B 3A42          FDB   $3A42
1F1D 3B42          FDB   $3B42
1F1F 3C42          FDB   $3C42
1F21 0001          FDB   $0001
          * COL 6
1F23 3D42          FDB   $3D42
1F25 3E42          FDB   $3E42
1F27 3F42          FDB   $3F42
1F29 4042          FDB   $4042
1F2B 0001          FDB   $0001
1F2D 0001          FDB   $0001
1F2F 4703          FDB   $4703
1F31 0001          FDB   $0001
1F33 3742          FDB   $3742
1F35 3842          FDB   $3842
1F37 3942          FDB   $3942
1F39 0001          FDB   $0001
1F3B 3A42          FDB   $3A42
1F3D 3B42          FDB   $3B42
1F3F 3C42          FDB   $3C42
1F41 4442          FDB   $4442
1F43 3D42          FDB   $3D42
1F45 3E42          FDB   $3E42
1F47 3F42          FDB   $3F42
1F49 4042          FDB   $4042
1F4B 0001          FDB   $0001
1F4D 0001          FDB   $0001
1F4F 4702          FDB   $4702
1F51 4802          FDB   $4802
1F53 3742          FDB   $3742
1F55 3842          FDB   $3842
1F57 3942          FDB   $3942
1F59 0001          FDB   $0001
1F5B 3A42          FDB   $3A42
1F5D 3B42          FDB   $3B42
1F5F 3C42          FDB   $3C42
1F61 4442          FDB   $4442
1F63 3D42          FDB   $3D42
1F65 3E42          FDB   $3E42
1F67 3F42          FDB   $3F42
1F69 4042          FDB   $4042
1F6B 0001          FDB   $0001
1F6D 0001          FDB   $0001
1F6F 4702          FDB   $4702
1F71 4802          FDB   $4802
          * COL 7
1F73 3743          FDB   $3743
1F75 3843          FDB   $3843
1F77 3943          FDB   $3943
1F79 0001          FDB   $0001
1F7B 3A43          FDB   $3A43
1F7D 3B43          FDB   $3B43
1F7F 3C43          FDB   $3C43
1F81 4443          FDB   $4443
1F83 3D43          FDB   $3D43
1F85 3E43          FDB   $3E43
1F87 3F43          FDB   $3F43
1F89 4043          FDB   $4043
1F8B 0001          FDB   $0001
1F8D 0001          FDB   $0001
1F8F 4703          FDB   $4703
1F91 4803          FDB   $4803

A048               ORG   $A048
A048 1B36          FDB   UNAS
                   END

PRPIA  801C
SSAV   1B08
OPER   1B08
SAVA   1B0A
TMP    1B0B
BAR    1B0D
LIN    1B0E
UNAS   1B36
AGN    1B3C
NOC    1B50
NOD    1B5C
MORE   1B87
NOE    1B9F
NOF    1BA5
NOG    1BAE
BREG   1BD5
SREG   1BD7
NOTBAD 1BEC
IMM    1C07
NOTIMM 1C0C
NOOPR  1C2C
INDXD  1C3B
NOTX   1C45
NOLAB  1C62
REL    1C68
NNREL  1C6F
CBH    1C7D
CBHLH  1C86
CBHRH  1C8A
CBHOK  1C94
BINIT  1C97
PDATA2 1CA2
PDATA1 1CA5
OUTCH  1CAC
PLUP   1CB2
MNET   1CB8
OPS    1D93

TOTAL ERRORS 00000
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KILOBAUD KLASSROOM NO. 3

George Young
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JK Flip-Flops and Clocked Logic

In our last class we met and became acquainted with the 7400 NAND gate, the Set/Reset flip-flop, and 7-segment displays. We tackled the truth table, the color code, haywiring, and had some pointers on soldering. We discussed how to incorporate some of the circuits into the console. And we promised to give you the answers to our resistor quiz. Here they are:

a) 22,000 5%
b) 270 10%
c) 39 2%
d) 4700 10%
e) 2.7 10%
f) 1000 10% ½ W
g) 1,200,000 5% 1 W
h) 100 10% ¼ W
i) 120,000 5% ¼ W
j) 8200 10% ½ W
k) 10,000 10% 1 W
l) 5600 5% 2 W
m) 2200 2% 1/8 W
n) 82,000 5% ¼ W
o) 6.2 3% 1 W
p) 1500 20% ½ W
q) 5 10% 2 W
r) 4,700,000 10% ¼ W
s) 75 5% ½ W
t) 120 4% ½ W

Preview

In this session we will tackle the J/K flip-flop, binary counting, decimal conversions, and the hexadecimal number system. We'll meet the seven-segment decoder, the LED register, and we'll breadboard the console clock circuit. After we cover the J/K flip-flop let's have a little diversion from our learning. Let's make an electronic toy. We'll also learn a new clock circuit and what is meant by "gating a signal".

Experiment #10
The J/K Flip-flop

Purpose: To introduce another digital building block, the flip-flop.

Equipment: Two 7473 integrated circuits.

New Symbols: a. The 7473 J/K flip-flop and pinouts (Fig. 1a). b. Test circuit for the 7473 (Fig. 1b).

Procedure: First, let's test the 7473. The start-stop control on the console is used to generate pulses. For each pair of pushes, one start, one stop, a single pulse out will be produced. That is, the start-stop output line (output bolt on the console) will go from Lo to Hi and back to Lo. This pulse is drawn next to pin 1, the clock input (Fig. 1b). Configure the 7473 on the student console breadboard as shown in Fig. 1b. (Note that +5V goes to pin 4 and ground goes to pin 11.) Each pulse will cause the flip-flop to toggle, or change state. These changes can be seen at both the Q and $\overline{Q}$ outputs of each flip-flop. Each 7473 has two flip-flops inside one IC package. Connect the logic probe of the console to pin 12. Press the start and stop control buttons to generate a pulse. The LEDs of the logic probe should change when the stop button is pushed. Press them again to generate another pulse. The logic probe LEDs should change again. Move the logic probe to pin 13 and repeat. The flip-flop should again toggle.

Each of the Q and $\overline{Q}$ outputs should change state as the clock input is pulsed or clocked by operating the start-stop control. The small circle with a wedge at the clock input indicates that the flip-flop is clocked on the Hi-to-Lo transition of the clock pulse (which is why the flip-flop changed state when the stop button was pushed).

The reset line *is tested* next. The small circle at the bottom of the rectangle means that this flip-flop has an active low reset. That is, to reset the flip-flop, this input must be taken Lo, or grounded. This will cause all the Q outputs of both sections of the 7473 to go Lo. To see this happen, you must first make a Q output Hi by clocking the flip-flop. Now ground the reset line momentarily. The Q output that was

Hi should go Lo. We shall not concern ourselves with the J and K inputs to the 7473 at this time. We should note, however, that we are able to clock or toggle the flip-flop only when these inputs are floating or connected to a Hi.

To see the 7473 divide by four, connect the circuit of Fig. 1c on the breadboard. Reset both flip-flops (so that both Q outputs will be Lo to start) by momentarily touching the reset line to ground. Now press the start-stop control eight times to generate four pulses. The logic probe should indicate only one positive pulse out for four pulses in. The two flip-flops have divided the four input pulses into one output pulse. Repeat this process for the $\overline{Q}$ output. You should again get division by four, but this time it should be one negative pulse out for four positive pulses in.

The flip-flop is an indispensible digital building block. It is used for counting and storing data. It is the heart of memory chips — a 4K memory chip contains 4096 similar flip-flops for storage of digital data. We've only looked at the flip-flop with this experiment, but we'll study it in much more detail as we proceed.

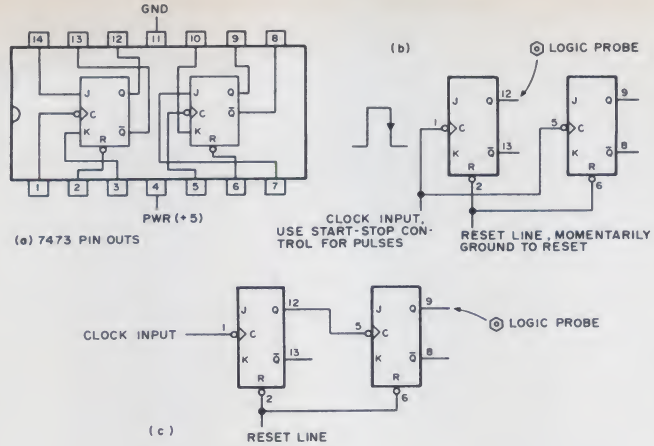


Fig. 1. 7473 J/K flip-flop.

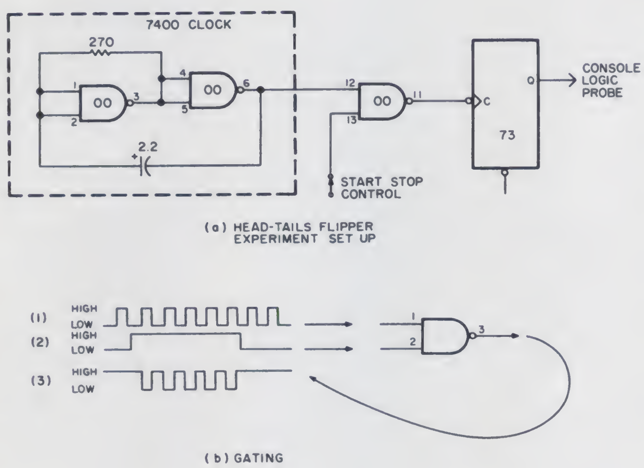


Fig. 2. Test setup and concepts for experiment #11.

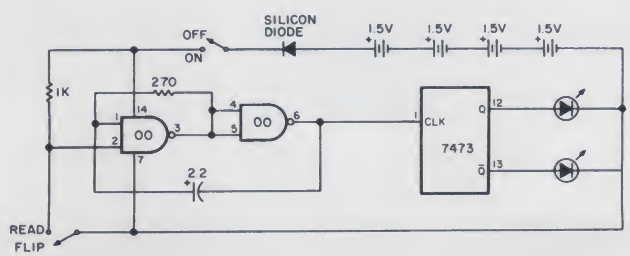


Fig. 3. Simple toy — a heads/tails flipper.

Experiment #11
A Heads-tails Flipper

Purpose: a. To make an electronic game (a heads-tail flipper circuit). b. To learn how to gate a signal. c. To construct a clock from a 7400 NAND gate.

Equipment: No new equipment is needed.

Symbols: No new symbols are introduced.

Circuit: Any clock generator could be used for the clock input in this circuit. But if we use a NAND gate for the clock generator, we have an extra advantage. Its use will allow us to make what is called a gated clock circuit utilizing the gate elements in one IC package. A gated clock allows us to turn the clock signal on or off with a control voltage. Fig. 2a shows how to make a clock generator from a 7400 IC. Note that the first three sections of the NAND gate package have the input pins tied together. This changes these gate elements into inverter elements, which means we actually have the same oscillator circuit as given in experiment #1. Fig. 2a shows in semi-block diagram the console setup for testing the heads-tails flipper circuit.

Recall that in a previous experiment I told you not to throw away your partially defective ICs? Here is a circuit that uses ½ of a 7473 and 3/4 of a 7400 Fig. 2a. This cost would be the same whether we used partially defective ICs or totally good ones.

The Concept of Gating

Refer to Fig. 2b. A Hi on pin 2 will enable the gate, and the clock pulses (the oscillator output) on pin 1 will then appear at the output pin (pin 3). The pulses will be inverted at the output, but that does not bother us *in* this case since all we want to do is to pass or block the pulses through the gate. This entire operation is illustrated in the *timing diagram* (Fig. 2b) which shows the oscillator pulses at pin 1, the high enable level at pin 2, and the gated pulses at pin 3. In performing the experiment using Fig. 2a, the start-stop control is used for the control voltage. Stop button depression produces a Lo output voltage, while start button depression produces a Hi output voltage. If you do not have the start-stop control functional yet on your console, a piece of wire connected to pin 13 and connected to ground will disable the gate, while this wire connected to + will enable the gate.

Note that I am starting to omit the pin-outs for the ICs on the diagrams. You have this information on preceding experiments thus far, and our intent is to have *you look up* the pin-outs in your data manual eventually. If the pin-outs are missing on a diagram, dig them out and write them on the diagram.

The clock signal that passes through the gate when the gate is enabled goes to the clock input of the 7473 and toggles it. The Q output of the 7473 is connected to the logic probe on the console. The logic probe has two LEDs, one for Hi, and one for Lo. Hi = heads and Lo = tails.

With the gate disabled, the toggling of the flip-flop stops, and we can read our "coin." To flip the coin, we enable the gate with a Hi on the control, toggle the flip-flop, and then disable the gate with a Lo so we can see if we get heads or tails.

The Heads-Tails Toy

Fig. 3 shows how to make the experiment circuit into a toy. The circuit can be haywired together and placed inside a plastic box with the control button on the cover. An on-off switch is desirable to conserve the batteries. In the next meeting we will learn how to make simple printed circuit boards. The heads-tails flipper is a most appropriate candidate for a simple printed circuit board project. Fig. 3 also shows another method of enabling – disabling a clock circuit. And it shows you how to use only ½ of a 7400 and ½ of a 7473 so that partially defective chips may be utilized.

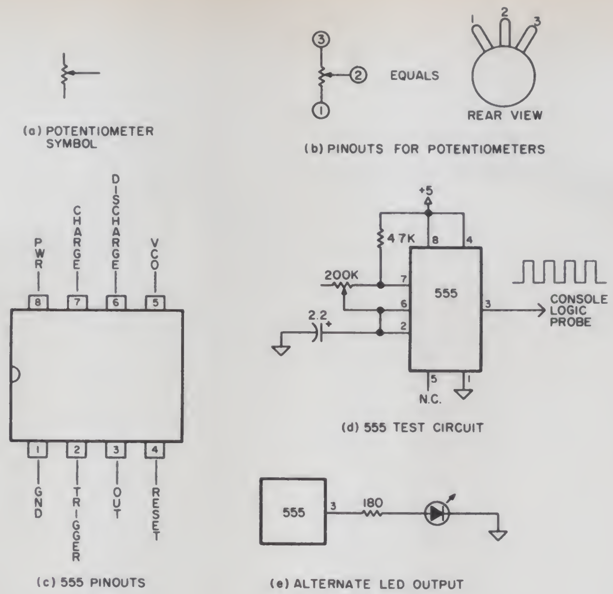


Fig. 4. New symbols for experiment #12.

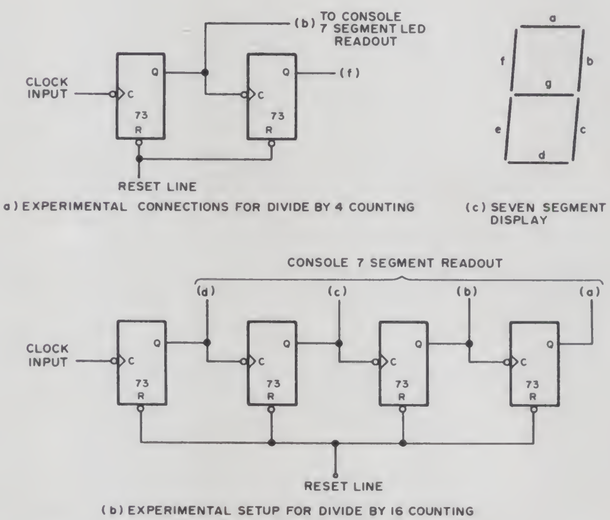


Fig. 5. Binary counting.

Experiment #12
The 555 and the Console Clock

Purpose: a. To investigate our first linear IC. b. To meet the potentiometer.

Equipment: a. 555 integrated circuit. b. A potentiometer between 50,000 and 500,000 Ohms.

Symbols: a. Potentiometer circuit (Fig. 4a). b. The relationship between the symbol and the potentiometer, or Fig. 4b. c. Pin-outs for the 555 chip Fig. 4c.

Circuit: Fig. 4d shows the circuit diagram for the 555 clock circuit. Fig. 4e shows how to connect an LED and a current limiting resistor if the console logic probe has not yet been made functional.

Theory: The 555 timer is one of the most versatile ICs made. It is intended for use as a timer, but it can also be used to make a larger number of different circuits. If you have the impression that it is one of my favorite chips, you're right. We are using the 555 here as an asynchronous multivibrator, or clock generator. We now have three clock generator circuits at our disposal. This circuit has an advantage over the 7400 or 7404 clock circuits in that the number of pulses per second, or speed can be easily adjusted by using a potentiometer. This little rascal will generate pulses from about 1 pps to over 100,000 pps, and is continuously adjustable. To change the basic range, only the timing capacitor in the circuit needs to be switched.

The pot here is connected as a variable resistor. That is, only two of the three terminals on the pot are connected. The unused terminal should be left unconnected, or it may be connected to terminal 2 on the pot.

The theory of the internal workings of the 555 is a little heavy for us at this point. The circuit given in Fig. 4d is a test circuit for the 555 chip. This circuit does not test all the functions of the 555, but it does provide a go no-go test.

Experiment #13
Binary Counting

Purpose: a. To study the principle of electronic counting. b. To learn to count to 100 in binary.

Equipment: The console needs to be completed except for the console clock. We have the other equipment needed for this experiment.

Circuit: See Fig. 5a.

Procedure: Set up the circuit in Fig. 5a on the console breadboard. The clock input will be the start-stop control on the console. We will use LEDs in the console 7-segment readout for indicators in this experiment. Don't forget to connect the LED readout common terminal to ground.

Theory: All LED segments out equals zero. The b segment of the 7-segment readout is assigned a value of 1 (see Fig. 5c). The f segment is assigned a value of 2. The symbol 2 is not a binary digit, since the binary number system has only two digits, 0 and 1. The number 2 is a decimal digit. To determine which number system is being used, the common practice is to either spell out the system, such as $2_{decimal}$ or use a subscript whenever a possibility of confusion may exist, such as 2_{10}.

Now, let's count to 4_{10} using two LEDs.

1. Momentarily ground the reset line. This will reset, or clear, the counter (flip-flops). The Q outputs will go Lo. The LEDs will go out. We have a zero indication.

2. Operate the start-stop control. Generate one pulse. The b LED should come on indicating that we have counted one pulse.

3. Operate the start-stop control again, generating a second pulse. The b LED should go out and the f LED should come on. We assigned a value of 2_{10} to the f LED

position. "On" is one, while "off" is zero. The 7-segment display is indicating a 10_2 (f segment on, b segment off). This is how a 2_{10} is written in the binary number system.

4. Operate the start-stop control again, generating another pulse. The f LED should remain on, the b segment should now also be on. A 2_{10} and a 1 makes a 3_{10}. The display indicates 11_2. This is how 3 is indicated in the binary number system.

5. Operate the start-stop control again, generating the fourth pulse. Both LEDs should go out. Now we know that we have counted to 4, but looking at the display, which is blank, we would have a devil of a time convincing anyone else that we had counted to 4. Where is the LED that tells us that we have counted to 4? It is in our own computer banks (our head). The presentation now displays 100_2 with the 00 on the console display and the 1 stored in our head. This is how 4 is written in the binary number system.

Note that I typed a bunch of 3s and 4s without writing a subscript. Since the symbols 3 and 4 do not occur in the binary number system, I must be referring to the decimal system. Subscripts need only be used if necessary to avoid confusion.

Fig. 5b shows two 7473 integrated circuits connected in cascade. Assign the value of 1 to d LED. Assign a value of 2 to the c LED. Assign a value of 4 to the b LED. Assign a value of 8 to the a LED. Note that we are the ones who are stipulating what values are assigned to each LED position. They mean what we say they mean.

Now you can count all the way to 16 in the decimal system before all the LEDs again go out (zero thru 15 = 16 digits). They all go out on count 17. By storing the 16, then the 32, then 48 and so forth, you can count as far as you want to remember the number of cycles that our counter has passed through.

DECIMAL	BINARY	HEXADECIMAL
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10
17	10001	11
18	10010	12
19	10011	13
20	10100	14
21	10101	15
22	10110	16
23	10111	17
24	11000	18
25	11001	19
26	11010	1A
27	11011	1B
28	11100	1C
29	11101	1D
30	11110	1E
31	11111	1F
32	100000	20

Fig. 6. Comparison of decimal, binary and hexadecimal.

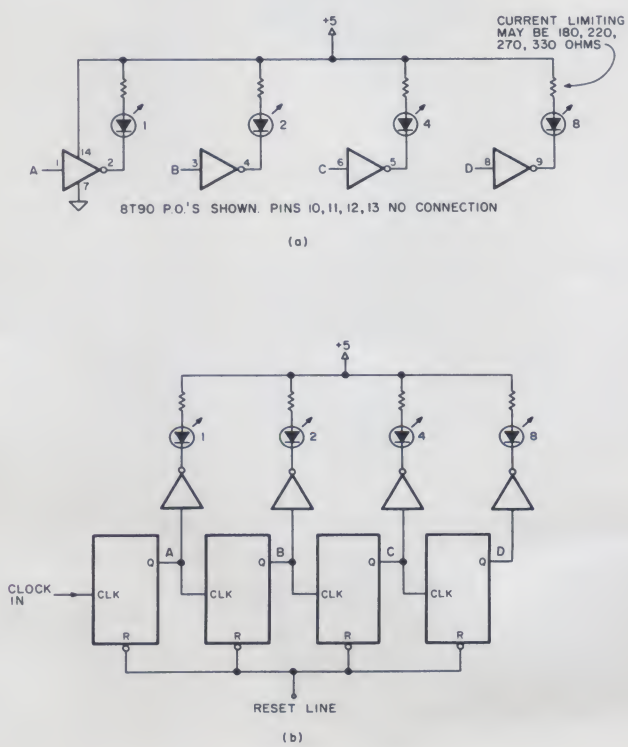


Fig. 7. LED register.

It would be nice if we had the equipment on hand to make an LED readout that we could arrange with the least significant bit (LSB) on the right, and the most significant bit (MSB) on the left. The best we can do with what we have at the moment is to arrange the readout in a more or less vertical fashion with the LSB on the bottom and the MSB on top. The display is then similar to the display in the photo.

The Number Systems

Electronic circuits count by twos. This is because electronic digital circuits are on or off, Hi or Lo, or 1 and 0. People, however, have ten fingers, and have learned to count and divide by ten. A number system based on ten different digits is a decimal system. A number system based on two digits is a binary number system. A number system based on 8 digits is an octal number system. If the ten digits of the decimal system are combined with six letters of the alphabet, we have 16 different symbols and the name hexadecimal is given to this number system. Fig. 6 is a table showing the relationship between three number systems: binary, decimal, and hexadecimal.

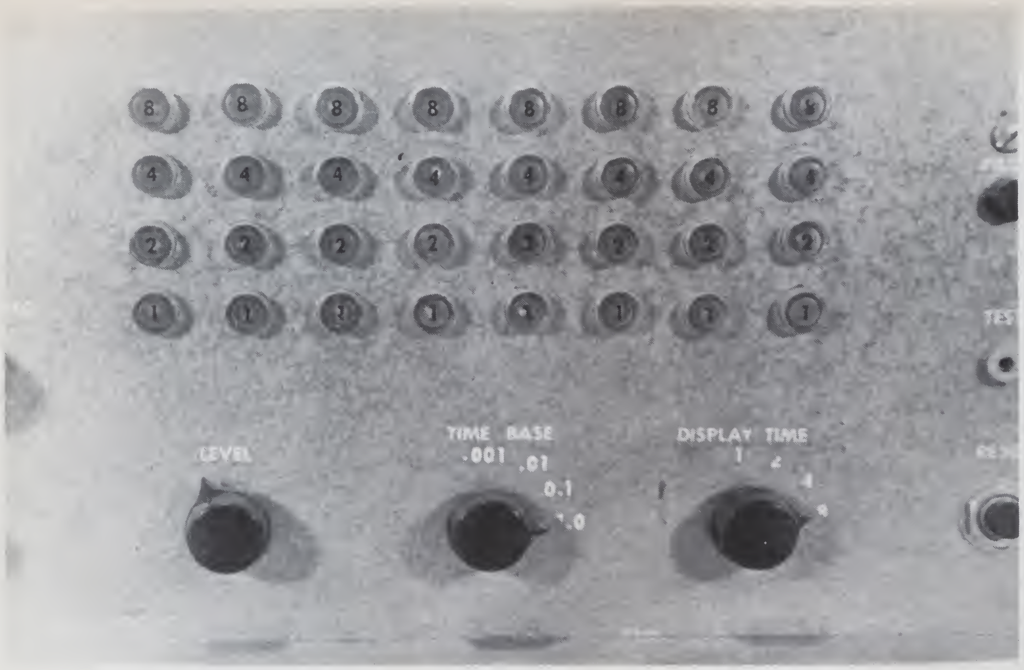
Experiment #14
The LED Register

Purpose: a. To make an LED register. b. To investigate binary coded decimal (BCD).

Equipment: a. An open collector hex inverter (8T90, 7406, 7416). b. 4 additional LEDs.

Symbols: No new symbols. The pin-outs on the 7406 and 7416 are identical to those of the 7404. The pin-outs of the 8T90 are given since this IC has slightly different pin-outs (see Fig. 7a).

Circuit: Refer to Fig. 7a for the LED register. Refer to Fig. 7b for the connection of the LED register to the counter.



Example of binary-coded-decimal.

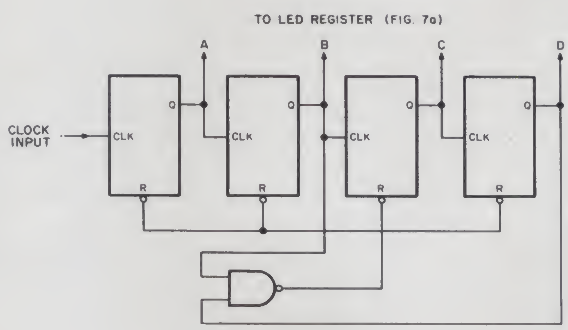


Fig. 8. Decade counter.

Procedure: Arrange the 4 LEDs in a vertical row toward the front edge of the console breadboard. Assign a value of 1 to the LED closest you. Assign a value of 8 to the LED farthest away, and values of 2 and 4 to the remaining 2 LEDs.

Connect the LED register in Fig. 7a first. All LEDs should be on. Then connect the LED register to the two 7473s that form the counter. Reset the counter stages to zero by momentarily grounding the reset line. All the LEDs should go out.

Apply pulses to the clock input of the counter. To start with, the console start-stop controls should be used. After the experiment is up and running (functioning), the counter can be clocked by the new 555 clock circuit. You should be able to make it count so fast that all the LEDs appear to be on at once. Rotate your entire console 90 degrees counterclockwise. This should place the LED register display on your right, with the LSB (LED assigned a value of 1) on the right, and the MSB (LED assigned a value of 8) toward the left.

The display will now read out in binary exactly as shown in Fig. 6. That is, the binary 1001, which is a weighted decimal 9 (8 + 1 = 9), will display the 8 LED and the 1 LED on, and the 2 and 4 LEDs off.

Not only is the binary now being displayed in the correct format, but the LED display of 1100 corresponds to the hexadecimal value of C, which is also correct.

After completing the next couple of experiments on decade counting, the console can again be rotated 90 degrees, and the BCD output of the decade counters can be seen as well.

Theory: The 8T90 (and 7406, 7416) are power hex inverters. They are specifically designed to drive LEDs, incandescent lamps, relays, and so forth. In this experiment, you could also use the 7404 since it will drive the LEDs satisfactorily.

Integrated circuits are capable of delivering a certain amount of power to other ICs or other devices. This is called *fan out* in the literature. The output of an IC drives a signal into a load of some kind. This may be the input to another IC or it may be some other device. If the load is heavy, the TTL output voltage may not swing to a high or a low. If this happens, then the device that receives the output as its input will not function properly. Most IC manufactures *specify* the input of a given IC as a normal TTL load, and they tell you in the data sheets for the IC how many of these standard loads the IC will drive and still retain its normal TTL output characteristics (i.e., its fan out capability or spec).

In the LED register of experiment #14, we are using the power hex inverter as a buffer stage, separating the LED loads from the Q outputs of the counter stages. The input of the hex inverter looks like only 1 standard TTL load to the Q outputs of the counter. We can also call this LED register an "interface circuit," since it is acting as a go-between for the LEDs and the counter.

Experiment #15 Conversion of Binary to Decimal

Purpose: a. To trick a binary counter into thinking it is a decimal counter. b. To determine methods of gating to allow division by other numbers.

Equipment: No new equipment is needed.

Circuit: Refer to Fig. 8.

Procedure: a. Start by researching all the necessary pin connections. They are all in the previous experiments. b. Reset the counter to zero. c. Use the start-stop control on the console to generate pulses. Count to 9_{10}. d. Add a pulse. Observe what happens.

Theory: A NAND gate's output is Lo only if all inputs are Hi. Upon resetting the counter, the B and the D outputs (2 and 8 output) of the counter are both Lo; the reset line is therefore Hi. After two pulses are counted, the B output is now Hi but the D output is still Lo. The reset line is still Hi. On the eighth pulse, the D output goes Hi, but the B output is now Lo so the reset line is

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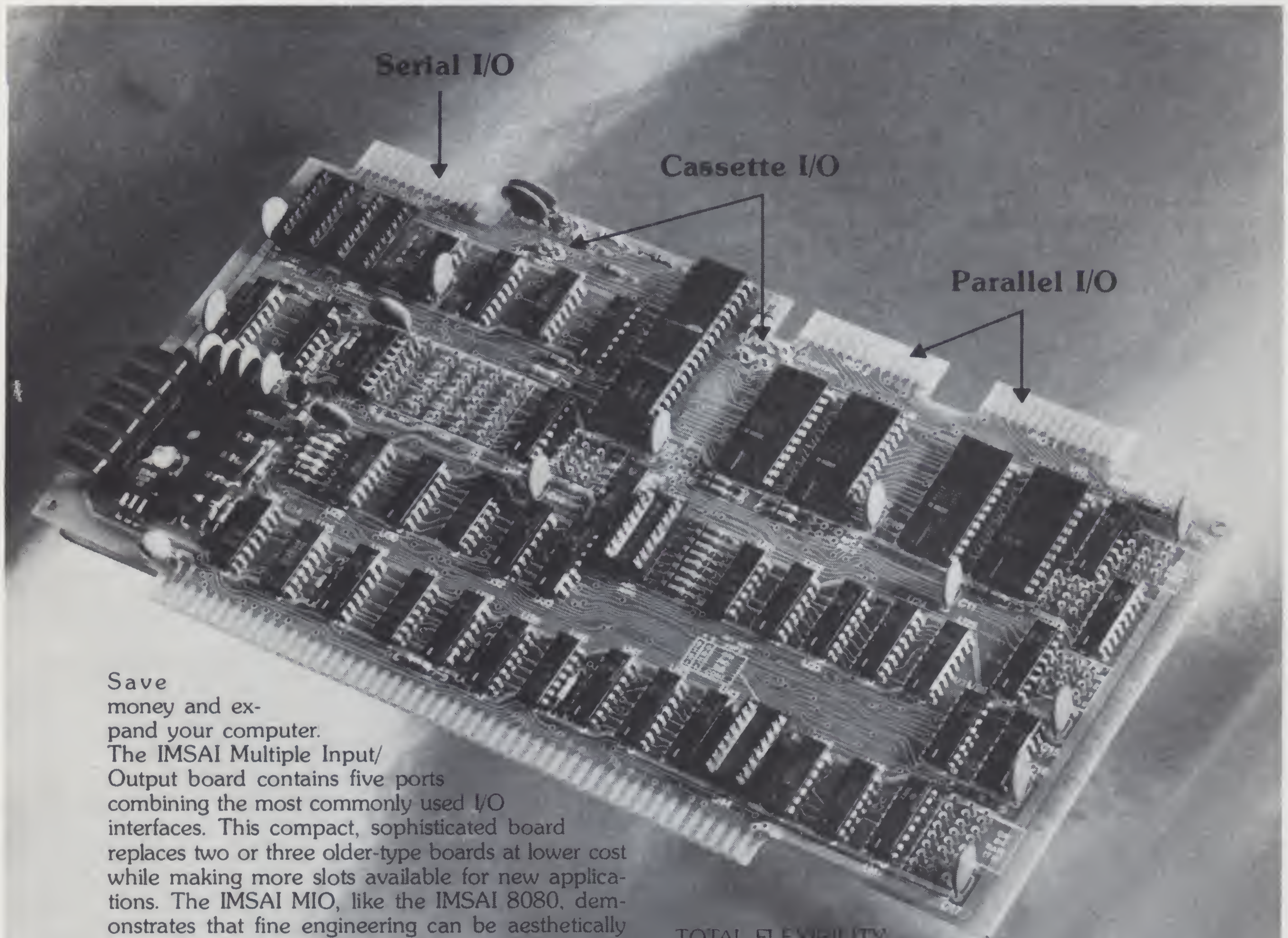

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still Hi. On the ninth pulse the A output goes Hi. On the tenth pulse, the B and the D outputs both go Hi. Both inputs to the NAND gate are now Hi. Its output goes Lo, resetting the B and D outputs to zero (the A and C outputs were already Lo). You will never see the 2 and 8 LEDs light. The counter resets so fast that the LEDs never get a chance to turn on. TTL logic is so fast that this resetting occurs in a few nanoseconds, (a nanosecond is 10^{-9} seconds) and you never get to see the count of 10_{10}. We have tricked our binary counter into dividing by 10 instead of by 16.

By gating the B and C outputs, we can make a divide-by-6 counter that might be used in making an electronic timepiece. Try it. Move the wire between the D output and the 7400 input from the D output to the B output. The counter will now divide by 6 instead of by 10. In fact, we can divide by 2, 3, 4, 5, 6, 8, 9, and 12 with this circuit and appropriate gating. We can't divide by 7, 11, 13, 14 or 15. Why? (Hint: There are NAND gates with more than 2 inputs.)

Experiment #16 The 7490 Decade Counter

Purpose: To investigate another digital building block IC (the 7490), and to learn how to use a decade counter for division by numbers other than 10.

Equipment: 7490 IC

Circuit: a. The 7490 pinouts (Fig. 9a). b. The 7490 test circuit (Fig. 9b). c. Connections of the 7490 to the LED register (Fig. 9c).

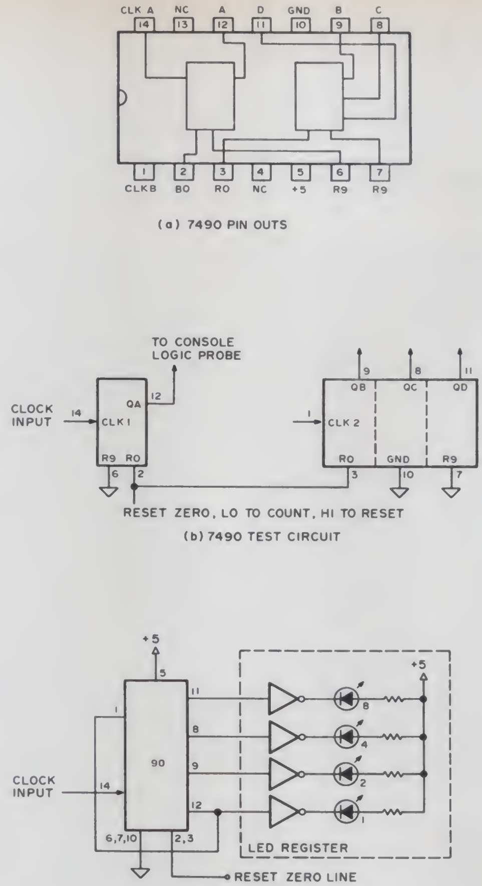
Procedures: 1) Test your 7490 using the circuit in Fig. 9b and the console start-stop circuit as a source of pulses. Use the console logic probe to verify that each of the outputs A, B, C, and D are toggling. 2) Set up the 7490 as a decade counter using the circuit in Fig. 9c. Again, arrange the LED readouts so that the LSB is nearest you and the MSB is farthest away from you. (The LED connected to the A output of the counter is nearest you, the D output LED indicator is farthest away.) 3) After verifying the 7490 operation as a decade (decimal) counter, make it divide by 6. Connect the B and C outputs to the reset zero pins (pins 2 and 3). Note that the POWER and GROUND connections for the 7490 are different from any preceding IC.

Theory: Decade counters are used to convert from machine language (binary) to human language (decimal). As we saw in experiment #13, four counter stages (flip-flops) are needed to count past 8. By adding gating, four flip-flops may be made to count in different modes. IC manufacturers make many different counters in binary (divide by 16), in decade (divide by 10), and in duodecimal (divide by 12). They make synchronous and nonsynchronous (called asychronous) counters. They make presettable counters. The 7490 was selected here because it is one of the most widely used and one of the least expensive.

The 7490 is actually two counter packages in one package. It has a divide-by-two stage and a divide-by-five stage, with separate clock inputs for each stage. To make a 7490 count with a weighted output of 8-4-2-1, which is called binary coded decimal (BCD) output, the clock signal is applied to pin 14, the clock input to the divide-by-two stage, and the output of this stage, *pin 12* is connected to the clock input for the divide-by-five stage, pin 1.

If a square wave output (equal on and off times) is desired, then the input is applied to pin 1 and pin 12 feeds pin 14. Connected in this fashion, the counter is a biquinary counter, and the outputs are the input signal divided by five, then 2.

Note that the reset function of the 7490 is the reverse

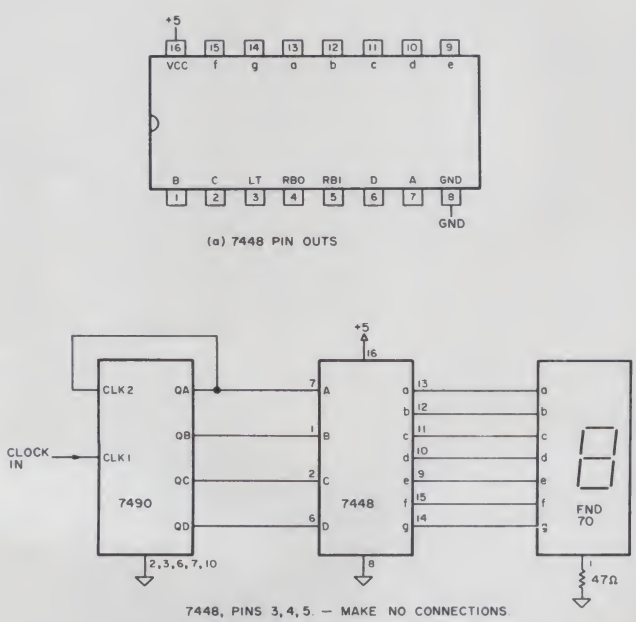


(a) 7490 PIN OUTS

(b) 7490 TEST CIRCUIT

(c) 7490 CONNECTION TO LED REGISTER

Fig. 9. 7490 Decade counter.



(a) 7448 PIN OUTS

(b) 7448 TEST CIRCUIT

Fig. 10. 7448 7-segment display decoder/driver.

of the reset function of the 7473. You must ground the reset pins of the 7490 to cause it to count. A high on both reset zero input pins will reset the 7490 so all outputs are zero, and it will not count with the reset pins Hi (note the absence of the circle at the reset inputs, indicating that a Hi resets). Pins 6 and 7 are called reset nine inputs, and will reset the 7490 so that the A and D outputs are both Hi. We do not use the reset nine function, and therefore pins 6 and 7 are grounded.

Finally, the gate that we added to the 7473 counter stages to make it divide by 10 is built into the 7490 IC package. Thus the 7490 incorporates all the chips that we used in experiment #13 in one IC package.

Experiment #17
The 7-Segment Decoder

Purpose: To introduce another IC and to bridge the gap between BCD readout and decimal display.

Equipment: A 7448 seven-segment decoder IC.

Symbol: Seven-segment decoders have no special IC symbol. They are normally drawn with 4 lines in and 7 lines out.

Circuit: Fig. 10a gives the pin outs for the 7448. Fig. 10b gives the test circuit for the 7448.

Procedure: Connect the circuit in Fig. 10b on the console breadboard. Reset the counter to zero and pulse the input to the counter with the start-stop control. The display will show the digits of the decimal system.

Theory: The BCD output of a counter stage can be fed to NAND, AND, and INVERTER elements so that the appropriate segments of a 7-segment readout will be energized to display numerals. Fortunately, for us, IC chips are available with all the gating elements already inside the package.

If all the outputs of a counter are Lo, this is a zero. To cause a 7-segment display to show the numeral zero, all segments except g must be energized. If the A, B, C and D outputs (all Lo) are fed to the A, B, C, and D inputs of the 7448 decoder, six of the seven output lines will go Hi, turning on all the segments of the 7-segment display except the g segment.

If a BCD 3 is output from the counter (both the A and B outputs are Hi) then the 7448 will turn on segments (a, b, c, d, and g) to display the 3. Even though the counter is counting in binary (0s and 1s) the display is in the decimal system (numerals 0-9). Thus we have a device to change machine language to human language.

The 7448 decoders have active Hi outputs. They were designed for the FND70 type of 7-segment decoder. Other 7-segment displays, such as Man 1s, require a decoder with active Lo outputs. The 7447 is the correct decoder for this type of 7-segment display. However, seven inverters (eight if the decimal point is also used) will allow you to invert the logic function and use a 7447 to drive an FND 70 readout, or seven inverters will allow you to drive a Man 1 display with the 7448 decoder.

Every electronic clock, calculator, electronic adding machine, etc. will use a circuit similar to Fig. 10b to display its decimal digits if it uses 7-segment readouts.

ICs and the Human Hand

ICs are the size we find them because of humans, and not because the chips are physically large. Humans require something they can see and hold in their hands to work with. Therefore, the IC package is many times larger than the chip itself. At our high school, we pop the lid off an IC package and peek inside with a microscope, allowing students to see that the chip is very tiny and the package it comes in is monstrous by comparison. If you can find a means of doing this, I strongly urge you to do so. It is about the only way that you can see how it is possible to put an entire microprocessor on one piece of silicon. This, more than any other factor, is responsible for the change in today's electronics. We no longer care what happens inside the chip package. We need only concern ourselves with what goes in and what comes out of the package.

Data Manuals

Of course, we need some foundation, background, and data on what goes in and what comes out in order to use the ICs. And where is that data? Well, some of it is in articles such as this, and in books, but the starting point is called a data sheet. The manufacturer sends out data sheets to all of the customers on his mailing list as soon as he has a new IC to offer. Since most of us don't buy thousands of chips, we are not on his mailing list and therefore never see the data sheets.

Periodically, the data sheets are compiled and published in a book called a data manual. If you plan to get very involved in electronics, you will need a data manual. They can be ordered from some of the advertisers in *Kilobaud*, purchased at electronics bookstores, computer shops, or from the manufacturers. I wrote Signetics, at 811 E. Arques Ave, Sunnyvale CA 94086 and asked for the price of the manual and name of the nearest distributor. They replied: $7.50, Hamilton-Avnet, 575 E. Middlefield Rd, Mountain View CA 94040. You can follow the same route to get your data manual. Signetics' manual covers their entire line, and National offers individual manuals for each IC family.

Preview

Next time we will begin making printed circuit boards. We will also get started on power supply construction and voltage regulation. We will need some copperclad board, and some material for a resist (I use Bitumol, bummed from the county road crew). We'll need some etchant. We will find some graph paper very handy, ruled ten lines to the inch. This can be obtained at your local stationery store, and while you're there, pick up a roll of Avery Self-Adhesive Correction Tape, Avery type CR16 (1/6 inch by 600 inches). This is handy stuff for tagging tested ICs, as well as for making temporary labels for various things.

The etchant can be either ferric chloride or ammonium persulfate. Ferric chloride lumps or crystals can be purchased from drugstores, chemical supply houses, or perhaps acquired from your local high school or junior college. Dissolve as much as you can in water. If you want to go the easy route, Suntronix Co. advertised a printed circuit kit in *Kilobaud* issue #2 for $14.95. They will give you a 10% discount if you mention Kilobaud Klassroom with your order. The kit has everything we'll need except the resist.

You can start scrounging now for the parts for the power supply. The most expensive item will be the power transformer. We will build our power supply using a transformer having a 1 Amp, 12 volt center-tapped secondary. There are many transformers that will prove suitable and you can even wind your own. We will also need two 1 Amp diodes, with a PIV (or PRV) of 25 or more, and a filter capacitor of 1000 uF or more at 15 volts dc or more. For the next article on voltage regulation, we will need an NPN power transistor with a 1 Amp minimum current capability; a zener diode between 5 and 9 volts, at ¼ Watt minimum; a three-terminal 5 volt IC regulator chip such as the LM309K or 7805, and a 723 voltage regulator chip. Sierra Electronics' price for this package is $5. ■

Digital Audio

... Part 3: Signal Expansion and Compression

Tom Scott
Uncalledfor Productions
Mill Valley CA 94941

In the first article in this series we examined the possibility of combining two great hobbies; home computing and hi-fi sound. We learned something about the process of digitizing audio signals; taking analog waveforms and converting them to a string of binary numbers. We considered some of the qualitative gains that might be possible through digitized sound recording. We also looked at some of the practical limitations to a digitized sound system or recording device.

In Part 2 we looked into the workings of some specific commercially available digital audio equipment; black boxes that can produce short time delays, change musical pitch and even musical tempo, or store short announcements. We also experimented with an Altair bus compatible analog-to-digital-to-analog converter, the Cromemco 7A+D I/O card. We found that it actually could handle music with fidelity acceptable for experimentation if the listener can overlook some limitations in frequency response and dynamic range.

This month we'll examine some of the possibilities of digital signal processing. Digitizing sound and storing it away is quite a trick, but while the analog waveform is encoded in a digital format, a computer can operate on the stream of numbers to produce signal manipulations that are impractical or even impossible using conventional audio circuitry. Let us examine digital methods applied to the amplitude (volume) and frequency (tone control) of sound information.

Volume control: compression and expansion

One of the more common pieces of audio control equipment is the *compressor*. Sometimes termed an automatic gain control (AGC), a compressor is an amplifier whose gain depends on the amplitude of the signal at its input. A small signal might pass unaffected, as though through a normal amplifier. A signal that exceeds a certain level, called the threshold, will cause the gain of the amplifier to be decreased. That signal will emerge from the output proportionately reduced in volume, or compressed (see Fig. 1). A variation on this device is the *peak limiter* or clipper. This is a compressor with a very heavy reduction in gain after the threshold is exceeded, effectively putting an upper limit to the size of the output signal.

AM radio stations use compressors to prevent overloading their transmitters with audio peaks while keeping the broadcast signal as loud as possible. Recording studios use limiters and compressors to put a punchy signal on tape and yet not ruin the tape recording with distortion from unexpected loud passages.

An *expander* is the opposite of a compressor. Where a compressor proportionately lowers the volume of louder sounds, an expander makes loud sounds louder. Some types of expanders can act as noise reducers by expanding musical program material away from such intruding soft noises as tape hiss or amplifier hum. Dolby and DBX noise reduction systems depend on the complementary use of compression before recording and expansion after to cover up or reduce the noise of conventional recording or transmission systems.

Compression devices don't act instantaneously however. It takes a specific *attack time* for the gain control circuitry to respond to peaks in the program audio and clamp down the amplifier gain. A digital delay line can be combined with a conventional compressor to form a *predictive* compressor. If the audio program is delayed by a short time equal to the attack time needed by the control circuits, the program will arrive at the controlled amplifier by the time that the gain is reduced. The device will seem to have predicted that a peak in program audio was coming.

All Digital Compression?

Perhaps the conventional gain controlled stage can be replaced altogether. Though no one to my knowledge sells one yet, it would be quite possible to create an all digital compressor/limiter. The data values of the digitized sound refer to real signal amplitudes at successive sampling times. Thus, to produce changes in the volume of the audio signal, the numbers in

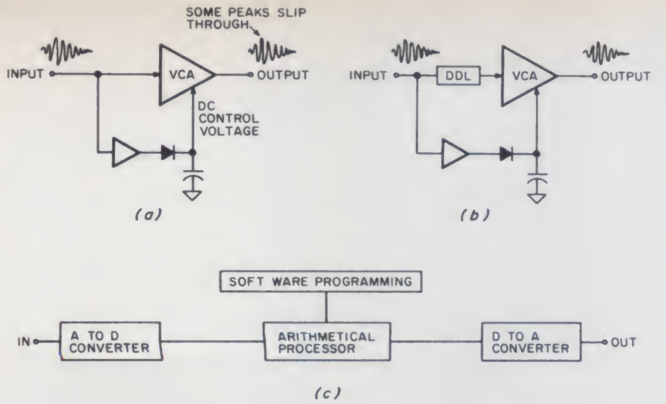


Fig. 1. Audio Compressors. (a) A Conventional Compressor: uses peaks from the input signal, amplified and rectified, to reduce the gain of a Voltage Controlled Amplifier (VCA). Since the action is not instantaneous, some fast peaks can slip through unattenuated. (b) A "Predictive" Compressor: incorporating a digital delay line (DDL), slows the arrival of peaks to the VCA to match the "attack" time of the control circuit. (c) An All-Digital Compressor: would operate on digitized audio, based on the "rules" applied to the processor, the device could emulate any compressor or expander.

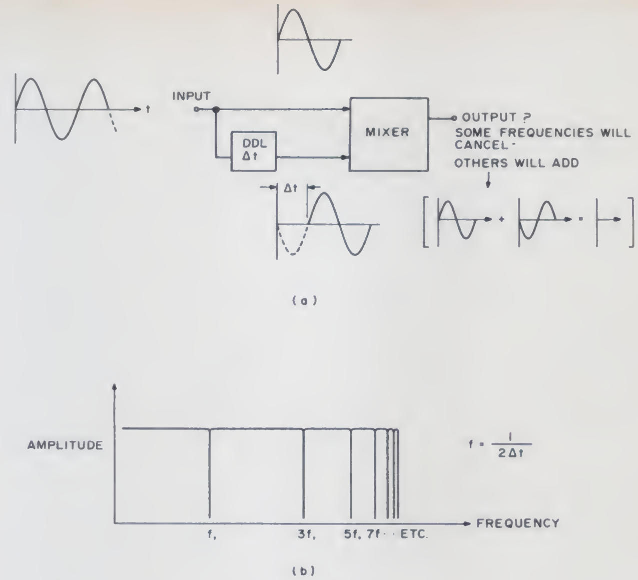


Fig. 2. The Comb Filter. (a) A comb filter utilizing a Digital Delay Line (DDL). (b) The frequency response of the comb filter. Note: Frequency is indicated on the conventional logarithmic scale; the notches occur at equal "numbers of Hertz" separation, but get closer together musically as frequency rises.

the data stream could be arithmetically scaled up or down by a microprocessor-style computer. By simply changing the programming of the computer we could apply any set of compressing, limiting, or expanding rules we chose. There could be an excellent hobbyist's project here.

Care would be necessary in the way rules were specified, however. Distortion of the audio waveform can creep in unless we proportion entire cycles of the signal. If we simply reduced the magnitude of signal values that exceeded a threshold, we might introduce unpleasant flat-topping of sine wave material in the output sound.

Digital Filtering

An interesting thing happens when a repetitive waveform is delayed by a few milliseconds and recombined with the original signal (see Fig. 2a). The combination of the two signal paths will have a very strange frequency response. The frequency whose period is twice the delay time will "cancel out" since, compared to the original, the delayed signal is moved over by ½ cycle (an audio engineer would say 180 degrees out-of-phase). This means that there will be a notch in the frequency response there and at a whole family of other frequencies that share the "moved over ½ cycle" attribute.

Make a sketch and you'll see that if the first frequency notch is at some frequency f, then the other notches will occur at 3f, 5f, 7f, etc. These notches are very sharp and numerous. The graphic representation of this sort of frequency response looks like Fig. 2b. From that, it's easy to see why this is called a *comb filter.*

Audio passed through a comb filter sounds strange. But things get even stranger when the time delay is varied (say with one of the variable DDLs we looked at last month). This causes the family of notches to sweep up and down through the audio spectrum to produce the jet-takeoff "whoosh" of the *phasing* or *flanging* effect familiar in pop music records. There are a few black boxes for sale that produce the effect in exactly this manner.

Incidentally, the term flanging comes from the old way of producing this effect, *a la* The Big Hurt. Two similar tape recorders simultaneously record the same material. Their outputs are combined, and instead of a DDL for variable delay, one machine is slowed down slightly by dragging one's thumb on the flange of the tape reel; hence flanging.

There are less frivolous applications for comb filters, however. Occasionally an incomplete shield on a microphone cord or a faulty ac ground can infect the audio program with a nasty hum and buzz that contains all the harmonics of the 60 Hz line frequency. A simple 60 Hz filter won't do; even after a set of filters at 60, 120, 240, and 480 Hz, there would still be substantial buzz left on the program audio because the harmonics extend to very high frequencies. Enter the comb filter. With two delays a pair of comb filter families can be constructed at 30 and 60 Hz that will notch out all the even and odd harmonics of 60 Hz, possibly retrieving a tape that might have been unusable.

Fourier Analysis

Computer processing of digitized sound can unveil some information that might otherwise be impossible to derive. The examination and analysis of the frequency spectrum of sound has been aided tremendously by A-to-D conversion techniques followed by computer processing of the digitized sound data. In theory, it is possible to take any repetitive waveform, no matter how complex, and break it down into a series of sine waves of various frequencies, phases, and amplitudes. This process is called a *Fourier Transform,* and it takes a lot of arithmetic to derive the complete spectrum of an arbitrary sound waveform. However, in this age of more refined computer techniques, some shortcuts have evolved.

In particular, the Fast Fourier Transform, or FFT, provides an algorithim (a set of repetitive steps suitable for computer solution) to derive a close approximation of the spectrum present in a given waveform. The computation starts with a series of numbers that correspond to amplitudes at successive sampling times (digitized audio, for example). After suitable arithmetic (a bit too complex for description here) the FFT algorithm yields another set of numbers that correspond to the amplitudes of each member of a set of frequen-

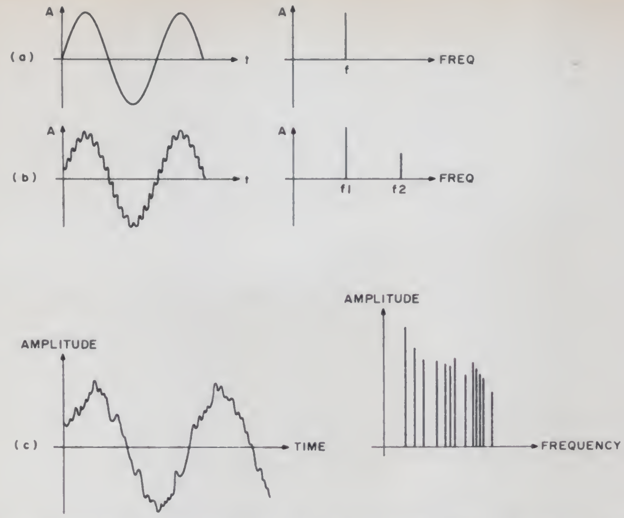


Fig. 3. Fourier Transform Plots. (a) A sine wave of the frequency f gives one line on the Fourier Transform (Spectrum) Plot. (b) The sum of two sine waves yields this spectral plot. (c) The Fourier Transform Plot on the right has a vertical line representing the contribution of each frequency present in the original waveform on the left.

cies sub-harmonically related to the sampling frequency. When these Fourier Transform values are arranged on a graph of amplitude-versus-frequency, we see the skeleton of a frequency response plot (Fig. 3a). You could think of this as the distribution of all possible frequencies present in the originally sampled waveform. If there are only one or two frequencies present in the originally sampled waveform, only one or two corresponding lines would appear in the Fourier Transform plot (see Figs. 2 and 3).

This transform from amplitude in time to amplitude in frequency can be a very powerful tool. By changing or deleting some of the numbers in the Fourier Transform data, we can produce the effect of tremendously complex analog filters, removing or augmenting the contribution of specific frequencies from the output analog waveform. Dr. Thomas G. Stockham, Jr., a leading expert in the digital signal processing field, has applied the technique to old recordings of Caruso with some astonishing results.

Caruso by Stockham

After the turn of the century record buying became a worldwide passion largely due to the enormous popularity of the Italian operatic tenor, Enrico Caruso. He virtually dominated the recording industry until his untimely death in 1921. He made many recordings, and since electrical recording had yet to be developed, almost all were recorded directly onto wax disks in a strictly accoustical manner. The sounds to be recorded entered a wooden horn, attached to a resonator which held a needle against the spinning wax recording surface. The sound vibrations were actually scratched onto the disk. As you can imagine, the system had fairly low fidelity.

The bandwidth of the mechanical system was 150 Hz to 3.5 kHz. The most prominent distortion, however, was produced by the mechanical resonance of the horn itself, creating huge peaks and notches in the frequency spectrum of the music recorded. You could approximate this by listening to your stereo through a long cardboard tube.

Dr. Stockham addressed his efforts to this mechanical resonance, since no ordinary analog techniques can even begin to rectify such complex spectral errors. First he digitized the program material from accoustically recorded disks in the RCA Victor archives, storing the digitized audio on the disk files of a PDP-11 computer. He then performed a Fourier Analysis on an entire musical piece. This yielded a kind of statistical frequency distribution for that particular musical performance, modified by the mechanical resonance of the recording horn. The problem then is how to separate the horn characteristic from that of the music: It's not unlike the high school algebra problem of two equations and three unknowns — somehow one unknown must be eliminated.

The key is simple in retrospect, just as Newton's prism experiments seem simple to us now. But often it requires brillance to unravel "obvious" truths. Stockham purchased a modern recording of the same piece of music (different orchestra and singer, same key), and performed the same sort of Fourier averaging. The difference between the *new* spectrum and the *old* is the filtering characteristic of the horn.

That's not exactly all there is to it, but I'm sure you get the idea. After isolating the horn's response, this horn quality could be subtracted from the Caruso recording and the resulting spectrum re-transformed to digitized audio amplitudes. This data could then be D-to-A converted back to sound, except that the sound now contains none of the peaky mechanical resonance.

This particular process is termed *blind deconvolution*. De-convolution can mean the removal of one characteristic transform from another (though the word *removal* is a poor word choice, albeit very graphic, because the process of convolution is parallel to multiplication in the analog world). The term *blind* is applied because we don't know what distortion must be corrected, or de-convolved, when the process is begun. Stockham became so proficient at this that he was eventually able to change the balance of voice to music and even remove the voice altogether, leaving the music. There is no analog filter that can do that!

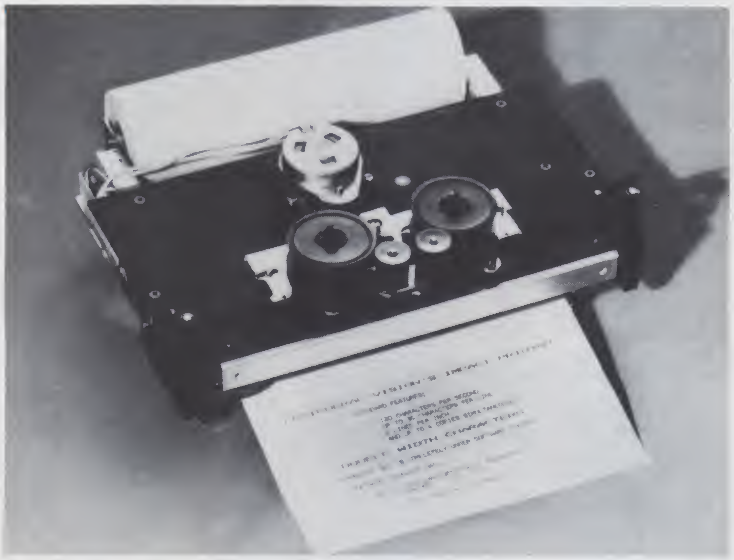
RCA has released a series of LPs featuring Caruso recordings re-constituted by just this means, and this could be the forerunner of much more digital audio processing. Dr. Stockham has indicated that this sort of analysis could be applied to, say, the listening environment in Carnegie Hall, or maybe the Taj Mahal. Imagine a recording studio where you could add Taj Mahal reverberation to your voice with the touch of a button.

The same sort of processing can also be applied to visual information. Photos blurred by motion or TV pictures fuzzed by faulty transmission can be re-constituted by de-convolution techniques. The Kennedy assassination pictures as well as the Mariner's views of Mars have recently been subjects for digital signal processing.

Fourier Analysis of the sounds produced by musical instruments can enable computer music enthusiasts to better capture the subtle timbres of wind instruments. Once the characteristics of a certain instrument have been unraveled by Fourier Transform, more convincing computer synthesis of brass and woodwind tones may not be far behind. Could a computer change a performance on a $50 fiddle to sound like one on a Stradivarius? I don't know, but I'm not discounting any possibilities.

Computer voice recognition by Fourier Analysis might be something that a hobbyists could experiment with. Is it possible that your Imsai might be trained to open your front door on command, responding only to you or your friends' voices speaking a nonsecret password? ■

Peripheral Vision impacts your computer.



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P12

It Was Great!

I arrived at The First West Coast Computer Faire on Saturday, April 16th around 9 AM and it was apparent that I'd done a good thing by pre-registering. Lines of computer enthusiasts were strung around the block. Pushing through the entrance with tape recorder and camera, I finally made my way into the huge exhibition hall and discovered that thousands were already crowded around exhibitors' booths. The *Silicon Gulch Gazette* had certainly done its job hailing the coming of the Faire.

The head count was 12,755, but onhand officials figured it was closer to 14,000, which means about 45,000 of you missed the Faire. So come along and share some of the happenings . . . without the press of crowds, din of voices and clash of computer-generated music.

To give you an idea of the enormous event, try to envision 170 exhibitors in an area that could accomodate a football field. Imagine trying to talk to everyone in two days and pick up every piece of literature offered while trying to permeate a throng of 14,000. I didn't quite reach my goal.

The lobby was crowded even before entering the "Faire grounds."

Every phase of personal computing was represented . . . 40 small vendors, a few of the "big guys," and the many who've been around for about as long as personal computing. Everyone had their special purpose for being there but large companies like 3M and National Semiconductor were there mainly to determine the market for their products. I guess we showed them, because they were quite impressed with the numbers and the excitement demonstrated by the crowd.

Most exhibitors were early entrants into the field and many are becoming quite sophisticated in their product lines and marketing approaches. Apple Computer, Processor Technology and Information Terminals Corporation are a few with very impressive looks. The newcomers' products provided competition offering new features or lower prices.

There was nowhere you could stand without hearing the tinkle of computer-generated music or the buzz of a line printer, or seeing games on CRTs that eighth graders were reprogramming. And if all that got to be too much, you could escape for an hour or two to one of the conferences held in separate areas throughout the building. The conference programs covered every conceivable topic from software and hardware tutorials, to personal computers for the physically disabled, computer graphics, computer-controlled energy storage systems and more.

Equipment Sampler

Let's take a random look at what some of the exhibitors had to offer.

The Logistics Synthesizer is a two-board package that simulates speech and music, in real time. And it understands. Imagine programming without a keyboard. Just talk to it . . . 120 characters per second is faster than anyone can type. Or have it talk to you. Or switch it to play your music on several instruments at one time. It's Altair bus compatible, and costs $525. Find out more from Logistics, Box 9970, Marina Del Rey CA 90291.

E, S & L Industries provides a wide variety of configurations in custom enclosures, tables and cabinets. They're rugged and good looking. They can provide in-stock standard enclosures for most of the popular

Sheila Clarke
CYBER GRAFIX
PO Box 430
Glendale CA 91206

... reviewing The First West Coast Computer Faire

computer devices, or they'll customize consoles and enclosures for you. They're at 867 S. Rose Place, Anaheim CA 92805.

An index of magazine articles has at last been compiled by E. Berg Publications. It's called *Periodical Guide for Computerists* and is priced at $2.50. The current publication covers 1976 articles from *PCC, Dr. Dobbs, SCCS Interface, Byte, EDN, Popular Electronics*, and many more. Cross references for article title, publication, and category make it handy. The next issue will be available in July and will cover articles written from January through June, 1977. E. Berg Publications is at 1360 S.W. 199th Ct., Aloha OR 97005.

Now you can interface a 40-function calculator array to your micro to give your application date and time information and perform algebraic and trigonometric calculating. The functions may be purchased separately in kit form, or both together on one board. Compu/Time T 102 interfaces a digital clock and calendar chip to your microcomputer, and Compu/Time CT 101 interfaces a calculator. The two together is model CT 100 ... the board is Altair bus com-

Interview with Lee Felsenstein: "At the moment the show is proving to be everything I hoped and feared it would be. It's a madhouse. On the other hand, it gives people a certain feeling of liveliness and the feeling pervades the place. I'm excited about the show. I want to see everything, talk to everyone and get everyone's manual.

"I believe this show is another of those plateau generating events. The field will not be the same after as before and I think we'll see this as a yearly event.

"Right now you must be special, a little crazy, a little rich, and put up with odd situations. People will if they want to do anything with a computer.

"But we have to develop a new name other than 'personal computing.' It sounds something like 'bean counting.' We'll know when the right name arrives. It'll click.

"I'm trying to make contact here basically with people who are attempting to use the computer with people attached for person-to-person communication. I'm interested in growing a computer assisted network and I notice that others are interested in the same sorts of things."

Lee is responsible for the Pennywhistle Modem, took part in designing the VDM-1 and SOL for Processor Technology and has a journal which he infrequently publishes, called Journal of Community Communications. *He has also been designated West Coast Editor for the soon-to-emerge* ROM Magazine.

At the Processory Technology exhibit, we talked to Bob Marsh for a moment. He was really up. "This is a fantastic show. We're getting a very favorable reaction. Now our emphasis is on entertainment. We're not selling individual "widgits" like we used to. We're demonstrating complete computer systems. One of our standard products (using the SOL) is a software system with a tape that has four games on it.

"I'm just amazed at the number of people who're coming here . . . especially since the admission is so high."

Bob, you couldn't keep us out.

patible, and the kit costs less than $200 (Faire special was $150). It's produced by RDC Enterprises, PO Box 417, Huntington Beach CA 92648.

Extensys Corporation introduced their 64K dynamic memory board (Model RM64) which can be purchased assembled and tested in increments of 32K, 48K or 64K. Prices range from $895 to $1495 respectively. It's Altair compatible, has dynamic refresh logic, board select logic to permit more than one 65K board per system, write protection and memory overlap. You may write them at 592 Weddell Dr., Suite 3, Sunnyvale CA 94086.

A lot of people were talking about the EQUINOX 100 Computer kit from Parasitic Engineering in Albany, California. The front panel has a reset switch and a 12-key pad with a key-operated power switch. It uses the 8080A CPU on an Altair bus board. The cover swings up away from the mainframe. The complete kit, at $699, can be expanded with the deluxe hardware kits #1 and 2.

Solid State Music's booth looked more like a candy store with dozens of kids who couldn't spend their pennies fast enough. Some of the products displayed included the SB-1 Synthesizer Board in kit and assembled, an 8K RAM board, a video interface, a 2K/4K EPROM board, and the announcement of their forthcoming 8K/16K EPROM kit. Solid State Music is located at 2102A Walsh Ave., Santa Clara CA 95050.

Technical Design Labs has come a long way since their Z-80 board, the ZPU, appeared in the marketplace. Two versions of the TDL Xitan Computer were introduced which handle their excellent ZAPPLE Software. Alpha 1 is an abbreviated features version of Alpha 2 which includes the ZPU, systems monitor board, 18K of memory that'll expand to 64K, Zapple monitor and 8K BASIC, a macro assembler, text output processor and Zapple text editor, and the power supply. TDL is at Research Park Bldg H, 1101 State Rd., Princeton NJ 08540.

Electronics retailers were well represented at the Faire. Jade Company set up a mini-store and appeared to be doing a landslide business. Their 30-page catalog covers a tremendous range of chips, clocks, ICs, kits, micro components, games, and more at very competitive prices. For a catalog, write 5351 W. 144th St., Lawndale CA 90260.

Newman Computer Exchange has several retail outlets throughout the country and specializes in computer related electronics and devices at reasonable prices. They'll send you a 64 page catalog if you write 1250 North Main St., Ann Arbor MI 48104.

You can get immediate delivery of terminals, modems and diskettes from ICS at 777 W. Middlefield Rd., Mountain View CA 94043.

IBM Selectric is often sought after as the ideal hard copy device. The Faire produced at least three manufacturers who can provide one in varying configurations. IBEX offers an interface kit for various models at prices from $450 to $475. Their address is 1010 Morse Ave., Sunnyvale CA 94086.

California Business Machines, 2211 The Alameda, Santa Clara CA 95050, provides a used Selectric, and interfacing hardware and software for

3M Marketing Manager, Roger H. Van Skoik, Jr. explains why 3M attended the Faire. "This is an emerging market, but it's more of a learning process for us. We're used to calling on big systems users and this represents a change in our market by having dealers which we didn't have before. We don't really know yet, but it's obvious by the number of people who are here that there is a really big interest."

By mid-Saturday the crowds were packed in.

prices from $649 to $695. Maintenance and repairs are left to the buyer.

A brand new Selectric especially converted for microprocessor use (any computer) and is fully warranted can be had for $1295 from Micro Computer Devices 564 S. Greenwood Ave., Montebello CA 90640.

Memory Boards

Custom Computer Systems offers an Altair RAM board with capacities ranging from 16K at $395 to 65K at $1295, assembled. They also have a 4K RAM board kit at $79.95 and a 6800 starter set for $84.95. They're at PO Box 5203, Orange CA 92667.

An "Intelligent RAM" board from Micromation Inc. is a jump-start 4K, Altair compatible kit or assembly for $145 or $190 respectively. Write them at 524 Union St., San Francisco CA 94133.

Micro Designs Inc., Oakland CA

Microdesign at 8187 Havasu Circle in Buena Park CA 90621 offered an 8K EPROM/RAM kit or assembly at $99.50 and $124.95.

Another 64K "memory system" beginning in increments from 32K comes from Prime Radix, Inc., PO Box 11245, Denver CO 80211. This extremely versatile looking board works together with a memory controller interface board which fit either an Altair bus structure or the Digital Group bus. Its a bit expensive with prices beginning at $1300.

PROROM, an 8K EPROM board from Mountain Hardware (Box 1133, Ben Lomond CA 95005) is Altair bus compatible kit for $164.00 with ½K of its full eight devoted to onboard RAM.

Computer Faire Wrap-up

It isn't over yet for the organizers. A final edition of the *Silicon Gulch Gazette*, which will cover the proceedings, will be mailed in about four to six weeks. If you have been receiving the newsletter, you'll automatically receive this one. If you are not on the mailing list, just write to PCC at Box 1579, Palo Alto, CA 94302 and ask to be included.

What About Next Year?

After the Faire I spoke with a member of Jim Warren's staff who said some exhibitors have already requested space reservations for next year. But doing it again next year is only under consideration right now. If they do plan a Second West Coast Computer Faire, I have one suggestion which might help the "bottleneck" at the entrance to the show which kept people waiting in line for an hour or more at times. If everyone had their badges

The Wizard's Eye Meta Image system doesn't really have a thing to do with hobby or personal computing . . . or does it? This computer portrait system uses a digitizer, printer, firmware and video camera. A freeze frame on the monitor lets you see what you'll look like before it's printed. The picture results in 32 rows of grays and takes about 20 seconds to print. The results can be reproduced for printing in a magazine. Wizard's Eye sells these systems to high-traffic tourist spots. I wonder what they were doing here?

The Digital Projects Line Printer particularly impressed us as being well suited to the hobbyist's needs, both technically and for its low price. With an Altair bus, 8-bit parallel interface to be available next July, it'll work for most computers. Digital Projects now has software available for the Z-80, the 8080 and 6800. Speed is 160 cps for the 132 character width, and kit price is $995. This one truly seems to compete well with the "big guys." The Digital Projects address is 1226 W. Maple St., Lompoc, CA 93436.

pinned on as they entered, waiting time would probably be diminished. This means that admission must be paid in advance by mail. It means even more organization than went into this event, and it means a lot of mailing. But perhaps it should be considered as part of a well organized, professionally run event.

A Few Conclusions

Everyone agreed that the First West Coast Computer Faire was a success. We learned a lot about computers in general, and were able to find out what we wished about specifics. Manufacturers with new products discovered whether they had a viable market. It is now

Top: Micro Computer Devices, Montebello CA; left: Smoke Signal Broadcasting, Hollywood CA; upper right: Vector Graphic Inc., Westlake Village CA; lower right: IMSAI, San Leandro CA.

apparent that the Altair bus structure is the microcomputer industry standard. The "big guys" were fascinated that all this was even happening. I was fascinated that 10-year-old kids could program in BASIC as fast as I could think. Wives found that their husbands weren't crazy after all — or at least that they were in good company with thousands of others. New organizations are now forming as a result of discoveries at the Faire. And Chairperson Jim Warren is probably in a state of collapse. But he and his staff are to be congratulated for an excellent job of pulling together the largest congregation of microcomputer enthusiasts in history. ■

Top: iCOM Microperipherals, Canoga Park CA; center left: Godbout Electronics, Oakland Airport CA; lower left: National Semiconductor, Santa Clara CA; lower right: Wave Mate, Gardena CA.

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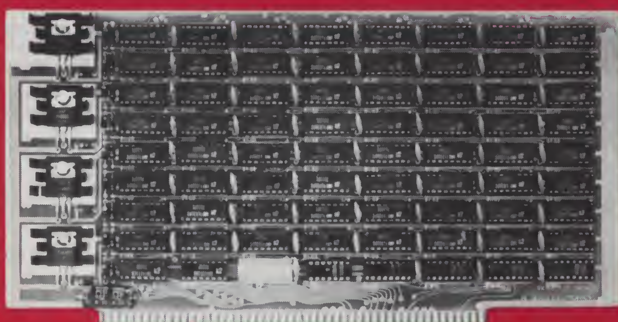

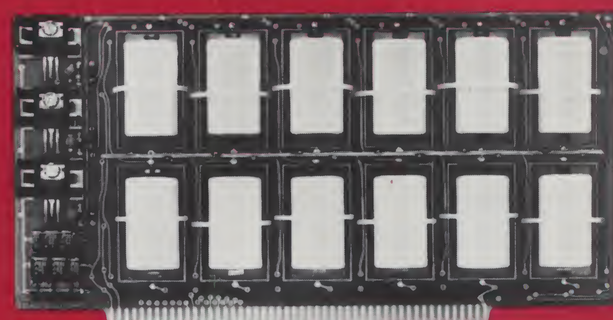

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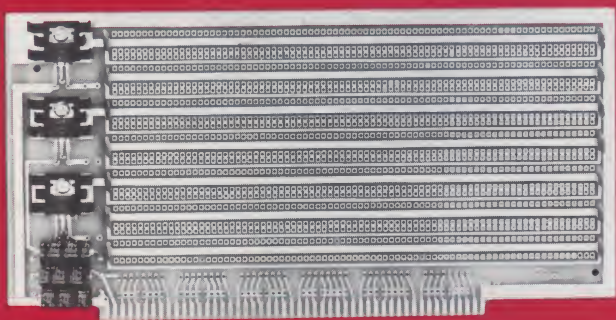

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LETTERS

from page 18

stand (a) electronics and (b) programming. They start at about the level of knowledge I am determined to have in six months. Right now, I can understand them just well enough to know that if I can just get by the initial barrier, KIM will do anything I want it to. But at this stage of the game, after only a couple of months, KIM is still a lot smarter than I am.

Wallace Kendall
Ellicott City MD

A Practical Approach To Math

Not long ago I received the April, 1977 issue of your very fine magazine, *Kilobaud*. Congratulations on the tremendous job you have done to bring to the interested public what I consider one of the, if not THE finest magazines devoted to the computer hobbyist field.

There are many points of excellence to be made clear regarding *Kilobaud*, but to mention just a few, I would like to commend you on putting the contents on the cover for quick and easy reference, the restriction of advertisers to those directly involved in the manufacture or sale of computer, interface, and instrument products (good show!!), and the diversity of articles – from fundamental to not-so-fundamental in both software and hardware. As a caution, please do not allow any card insertions that are all too common with the typical newsstand magazines (e.g., P-E and R-E, you get the picture), the bingo card at the back of the magazine should suffice for all advertisers.

Some things I would like to see included in *Kilobaud* include a list of the known computer organizations (I despise the term "club" as applied in this case) showing name, address, phone, and person to contact, as well as meeting dates and locations; a list of recommended books on different aspects of the computer field, indicating the difficulty of content and whether it is for software or hardware applications or both; I would like to see each article/section printed in its serial entirety, if possible (how do others feel about this?). No one should be upset if his/her article appears toward the back of the magazine. In fact, a way to preclude this difficulty, should it ever arise, would be to print the articles in alphabetical order by author. A little more professionalism in structure wouldn't hurt at all.

I would like to comment at this time on the letter submitted by Glen Charnock of Oxnard CA (p. 115, April, '77). On the whole, I support Mr. Charnock's attitude toward the use and presentation of mathematics as applied to computer programming and technique. I do, however, feel it to be presumptuous of Glen to suppose that the greater portion of your readership come from the professional ranks of computer technology. I believe this issue would be resolved by a poll or survey. Mr. Charnock is quite right however, in asserting that mathematics is a tool to be used for the solution of problems and is not a "problem" in and of itself. I believe that *Kilobaud* can take a quantum leap forward by introducing mathematics in a logical and rational manner as it applies or can be applied to the solution of real, common (everyday), or even not so common problems. Here is an opportunity of getting out of the TV ping-pong, tennis, hockey, what-have-you syndrome (which is a dead-end anyway) and moving into new, useful,

and challenging areas. I'm not against computer games, as they most certainly have their place and are desirable as an entertaining means of being introduced to the capability of just a few bytes of memory. I now ask this: "Do you want to play games all of the time?" I think not. In any event, to get back to the "bit-stream," a mathematical approach to applications software is a chance for all those "computer freaks," as Mr. Charnock puts it, to contribute their share by submitting articles or even just a letter concerning their particular application or need for help in pursuing an application. As an added attraction(?), by the gentle introduction of mathematics, side by side programming could be developed in both BASIC and FORTRAN, or practically any other relevant language. I'm with Mr. Charnock! I'm not (too) afraid of "the big bad math."

Coming near the end. While I certainly cannot expect to become a millionaire by writing articles for *Kilobaud*, nevertheless I would appreciate it if you would forward to me an author's guide. I guess I'll have to join the KMK after all!

Well! Thanks very much for allowing me to bend your ears for a short while. I must reiterate my congratulations on a job being well done! Keep it coming!

V. Davis Bennight
San Francisco CA

Don't worry about those card insertions in KB, *Davis. List of "organizations" – fine, I'm interested. – John.*

Tic-tac-?

The article "Bridging the Gap" by David E. Stanfield on page 90 of the May, 1977 issue of *Kilobaud* was well-written and interesting. However, it unfortunately used an erroneous tic-tac-toe game evaluation. Of course, an incorrect tic-tac-toe algorithm is not a serious matter, but the same type of mistake could occur in a practical program.

I admit that I have seen the same erroneous tic-tac-toe game evaluation in some books on games, but that does not justify perpetuation of the error. An accurate evaluation is given in Martin Gardner's *Mathematical Puzzles & Diversions*, pages 37 through 46. The center opening game is actually the weakest (rather than the strongest), the side opening game is intermediate (rather than the weakest), while the corner opening game is the strongest (rather than intermediate). This common evaluation error comes from looking at the number of possible ways to complete a row-of-three (starting with the given opening) instead of looking at the number of ways in which an opponent can block a winning strategy. A winning strategy involves setting a trap (a "fork"), so that the opponent can block only one of two possible ways of winning. It is assumed that any opponent will block an obvious row-of-three.

For the center opening game, the opponent has four relatively obvious moves (to any of the four corners) to block a potential "fork." For a side opening game, the opponent has four less obvious moves (the three adjacent cells or the opposite side) to block a potential "fork." In addition, there is a second possibility of a trap if the opponent chooses the opposite side; on the second round, the opponent can be left with only one correct (and non-obvious) move to block a potential "fork," out of six possible moves. The strongest opening, a corner move, has only one correct response out of eight possible moves. Any incorrect response results in an immediate trap, if played correctly. In addition, even with a correct response (to the center), the opponent can on the second round be

left with two responses (to the center), the opponent can on the second round be left with two responses out of six that will again allow the setting of a "fork."

Lest you may think that this "perfect" tic-tac-toe strategy would be too lengthy to program for a microcomputer, I have written a program in 224 bytes (plus 182 bytes for the required register contents) that will play such a game on an HP-67 programmable calculator. The program pseudo-randomly chooses a center, corner, or side opening; it has alternate strategies for the same initial user response; it displays the current move plus the updated board after each move; and it signals when it wins, whether from a "fork" or from a simple user mistake.

I realize that some games are deliberately programmed imperfectly, to avoid discouraging the user. However this article did not have a disclaimer to that effect.

Playing a rational game of tic-tac-toe is much more involved than merely playing an unbeatable game; it requires playing so as to maximize the chances of winning, which is quite a different matter.

Delmer D. Hinrichs
Washougal WA

Reply

Dear Delmer,

I want to thank you for your very informative letter. After I made several fruitless attempts to locate the material by Martin Gardner, I decided to dig out the information the hard way. Toward that end, I played out 111 games of tic-tac-toe, which really ruined my Saturday afternoon.

I concluded that you were quite correct with respect to a fair player who will block any obvious two-in-a-row combination from taking the third square and the game. I decided my analysis was still correct with respect to neophyte players and I found that the player who moved first was able to win the majority of those games which were actually won — no matter where he started from. Finally, I concluded that advanced players will always play to a draw unless one makes a careless mistake.

Delmer, I'm sending a copy of this letter to *Kilobaud* because in the course of my investigations, I discovered a flaw in one of the flowcharts I used in my article.

Contrary to what I thought at the time I was writing the article, it is possible to occasionally lose a game when following the flowcharts I set up. In every case, this results from the opponent setting up a fork, exactly as you wrote would be the case.

For whatever it's worth, here is what happened. While I was writing the article I decided that I wanted to give the reader an idea of how a problem is broken down prior to programming. I selected the game of tic-tac-toe because it is well known, simple enough to be covered in a brief article, and more interesting than adding columns of figures.

I then analyzed the game as I saw it and developed the flowcharts based upon a system I had successfully used when I played tic-tac-toe in grammer school. I checked out the flowcharts by playing several games in the fashion they indicated and they all came out as I expected. Once I mailed out the article, I didn't give it any more thought until your letter arrived.

Looking back, I see that the reason I analyzed the game the way I did was that I had done most of my playing years earlier against other children. It really wasn't unusual for them to ignore my having two-in-row and allow me to win in this simple manner. As my playing improved, I developed the habit of mentally checking the results of my

moves before I made them. This allowed me to avoid forks or to set them up. But it was this step that I forgot to include in my article.

I apologize to you and any other readers of the article for my omission. And again, I thank you for taking the time to write.

David E. Stanfield
Atlanta GA

Observations

Just a couple of words on some of the advertisers – of *KB* and *73*. Please note that these are only my observations.

About 2 months ago, I ordered a cassette interface directly from SWTPC. Well, for a month of backorder notices I wanted my money back. I called the Micro Store in Richardson, Texas, and the unit was on my doorstep the very next day. Real good people. That was the good news, now the bad. About 7 months ago, I got involved with Mini-MicroMart of Syracuse NY. I bought one of their RM Terminal units to use with my ham RTTY. This was a good deal for the money, and it worked quite well. At the time, they were having a contest for applications using this terminal, and after submitting a couple of articles to them, I won first prize which was $100 worth of free merchandise. What better time to get into all this Micro stuff? Well, I bought their RM6800 board, RM4K board and ASCII to baudot & baudot to ASCII converters (the original rm terminal is a baudot device). At the time, I lived in Northern Maine, and there was only myself and one other person who was even slightly involved in computer stuff, so information crossfeed was next to nil. Happily, I was transferred to Austin, Texas, where I met up with the Central Texas Computer Association, and got some badly needed help. The main problem with the MMM products is the numerous amount of corrections necessary to get the system running. I believe that if they would improve their Quality Control of the final board layout, and expend a few funds on improved documentation – a schematic and parts layout is really not enough, especially when you don't know which is right, the schematic or the board – they would have a good product. With the 4K board, I performed all the "necessary" board modifications with my X-Acto knife, and it still didn't work. After many conversations with MMM, I continually got more information from them – like replacing a 7400 with a 7403, etc., but it still didn't work. Well, they gave me the name of an individual who had gotten the board working, in Florida. After a few conversations with him, I learned that I didn't need to do any of the "required" modifications, because it would work as received. They designed the board to work with their 8080 system or the 6800 system, and the mods weren't required for the 6800 system. In addition to these problems which I have had, I have talked to some other people here in the Austin area who have different boards of MMM, and their experiences have been parallel to mine.

As I said, these are only my observations, but I definitely would not recommend MMM to anyone who doesn't have a thorough understanding of the system which they are going to buy.

Tim Ahrens
Austin TX

Thanks, Tim. You know, I'm getting downright tired of hearing about experiences like this with Mini-MicroMart (and I've been hearing them for two and one half years!). I tell you what . . . I'll look very carefully through the mail next month and see if I can find a good letter about MMM. – John.

Pass the Buck

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Phil Feldman
1722 Brockton Ave.
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Tom Rugg
1115 N. Beverly Glen Blvd.
Los Angeles CA 90024

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Before discussing the actual program, a quick look at the theory of decision-making will probably prove useful.

How Do You Make Decisions?

Have you ever thought about how you make decisions? What processes transpire? Do you react emotionally? Logically? A strange mixture of both? Are you happy with the decisions you make, and with the process you go through to make them?

Human consciousness is typically considered to have three aspects: perception, emotion, and logic. All three have a vital role in the decision-making process.

Perception enables us to sense our outside environment and translate its stimuli into our own "working model" of the world. Thus it provides the raw data with which emotion and logic will work.

Emotion serves to guide our choice of values. It leads us to our preferences and dislikes in a subjective manner. Many of our personal value judgments are made this way. However, when decisions are made purely on emotion, they tend to be erratic, irrational, and often hysterical in character. Frequently these decisions are later regretted.

Logic serves to produce a rational and consistent decision-making process. The consequences of each course of action are evaluated and the "best" alternative is selected. However, when decisions are made purely by logic, they tend to be somewhat sterile and lacking the true full range of our consciousness.

Clearly a happy medium among perception, emotion, and logic is the right way to go. It would be a little presumptuous to say that this program can strike the happy blend for you in all cases. But it can provide very useful insights and it will force you to think along proper lines when making a decision.

Utility, Utility, Utility

Before delving into the workings of the program, it is necessary to introduce a concept fundamental to its operation: utility. If you have ever rated things on a scale of say, one to ten, you were using utility though you probably didn't realize it. A utility function is a means of assigning numerical values to various outcomes and/or alternatives in our decision model.

The higher the value given to an alternative, the stronger the preference for it. Values may range from zero to infinity (i.e., any nonnegative number). The important thing in evaluating alternatives is the *ratio* of the numbers to each other, not their absolute value.

For example, suppose we are considering three colors for a car: red, white, and blue. Suppose we assign the values 10, 5, and 15 to red, white, and blue respectively. We are thus saying that we prefer white the least and consider red to be twice as desirable as white. Furthermore, blue is our favorite choice and is three times as desirable as white. Assignments of 2, 1, 3 or 100, 50, 150 would both be *identical* in meaning to the original assignment of 10, 5, and 15.

The program often asks that the user assign certain utility functions. Typically, one alternative is given a value of 10 and the user is asked to assign values to the other alternatives. Each alternative should then be assigned a value according to

its worth, or utility, relative to the base alternative.

Though not frequent, values of zero are possible in a utility function. Suppose we are trying to decide what type of residence to acquire and are considering a house, a condominium, or an apartment. We are then considering the investment potential of each choice. Our feeling is that the house would be twice as good as the condo. But both are much better than the apartment which really has a value of zero in terms of investment. However, the program proceeds to assign the apartment a value of 10 and then asks for relative values for the house and the condo.

The solution is to assign values for the house and condo which are each much larger than 10. A value of 2000 for the house and 1000 for the condo would be appropriate. If the ratio between two utilities is larger than 100, the alternative with the smaller value is essentially negligible compared to the other. Negative numbers, however, are never used in a utility function.

This concept of utility is used repeatedly in the program. The final output of the program is an overall utility function of the basic alternatives in the decision under consideration. More about utility will be discussed later in this article.

A Typical Scenario

Let's get into the workings of the program. The best way to familiarize yourself with its use is to consider a typical application. See Fig. 1 for the sample run discussed here.

The situation was this. A buyer of an automobile, we'll call him Joe, had narrowed his choice down to three cars. They were: Dodge Aspen, Volvo, and Chevy Nova. He considered his decision to be pretty close and wanted to use the program to help him make it. Joe decided to add a Rolls Royce to his list of alternatives when running the program. This was not really a serious possibility (Joe knew he couldn't really afford a Rolls, although he always had a pipe dream of owning one). He put it in the list as one way to check the validity of the program output. If the Rolls didn't come out pretty low, something was wrong somewhere!

The program begins by asking what type of decision is to be made. When Joe said that he wanted to choose a car, it then asked for the ones under consideration. His four cars were then duly entered.

Next Joe had to determine what factors were important to him in choosing a car. He came up with the following list of six factors: fuel economy, handling ease and comfort, aesthetics (i.e., looks and prestige value), maintenance, price, and safety.

The next required input was a utility function on the relative importance of each of these six factors. Joe considered price to be the single most important factor and the program then considered price to have a value of 10.

It then requested a relative value for each of the other five factors. Joe gave values ranging from 4 for aesthetics to 9 for fuel economy. For these five factors, only numbers greater than 0 and less than or equal to 10 were possible. A number greater than 10 would mean that that factor was more important than price; but price was considered to be the most important. A value of 0 would mean that that factor had no importance at all; in that case it shouldn't even be on the list.

The next step was to assign a utility function for each car with respect to each factor. For example, Joe had to come up with a value for each car considering fuel economy only, then considering handling only, etc. In each case the Dodge Aspen was assigned a value of 10 and every other car was rated relative to it. A value larger than 10 meant that Joe considered that car better than the Aspen in that respect. A value lower than 10 meant Joe thought it was worse than the Aspen. Let's look at Joe's input values.

For fuel economy, Joe gave the Volvo a slight advantage over the Nova and the Aspen, but the Rolls was considerably worse with a value of 3.

For handling ease and comfort, Joe gave the Aspen a slight edge over the Volvo and Nova. The Rolls was last again. Joe considered the Rolls quite comfortable, but its bulky size was awkward for him to handle, in his opinion.

In aesthetics though, the Rolls had a clear lead over the others in Joe's value system.

Maintenance produced a slight nod to the Nova which had a better repair record than the Aspen from the data Joe had gathered. The Volvo was given a lower value mainly because where Joe lived it was somewhat harder for him to find places that could service a Volvo. The Rolls was even further behind for the same reason plus the fact that repairs to it would be more costly than to the others.

Price saw a slight edge for the Nova over the Aspen. In Joe's financial condition, he considered that the somewhat higher price of the Volvo made it worth a 5 on this utility scale. The price of the Rolls was out of sight to Joe and this was reflected by his assignment of 2 to its price utility.

For safety, Joe gave the Rolls the highest value. He assumed its sheer size and weight would protect him in any accident. Volvo was next, with the Aspen and Nova a little behind.

Armed with all this data, the program ground away and arrived at an output utility function for the four cars. The list was normalized to give the best choice a value of 100 and then adjust the others accordingly.

How did Joe react to his output? It was about what he had expected. He had considered the Nova, Aspen, and Volvo all to be about equal. The somewhat lower showing of the Volvo (83.8) eliminated it from his consideration. The low rating of the Rolls Royce (53.2) was expected and at least gave him some confidence in the results. The Nova and the Aspen came out very close, with the Nova getting the nod.

Joe pondered a little more and then bought the Nova. Since this is a hypothetical story, we have decided to give it a happy ending. Joe is extremely happy with his car. He considers running this decision program to be one of the best uses he has found for his computer. Joe wants to thank Phil Feldman and Tom Rugg for sharing it with him. He especially wants to thank *Kilobaud* for publishing it. Joe did ask us to make it clear that he was not generally endorsing or slandering any cars, that they were only used for demonstration purposes, and he is not getting any royalties or kickbacks from Chevrolet. (He is, however, saving up for a Rolls Royce.)

How Does the Program Work?

The algorithm used by the program is really quite simple. Let's examine it.

The utility function with respect to the different factors are each normalized so they sum to 1. This is accomplished by summing the input values and then dividing *each value by this* sum to get the new value.

For example, when considering safety, Joe gave values of 10, 12, 10, 13 to the Aspen, Volvo, Nova, and Rolls respectively. These sum to 45. Now each of the four values were divided by 45 to get new values of .222, .267, .222, .289 respectively for the four cars. This normalization was done for each factor separately.

In a similar way, the values

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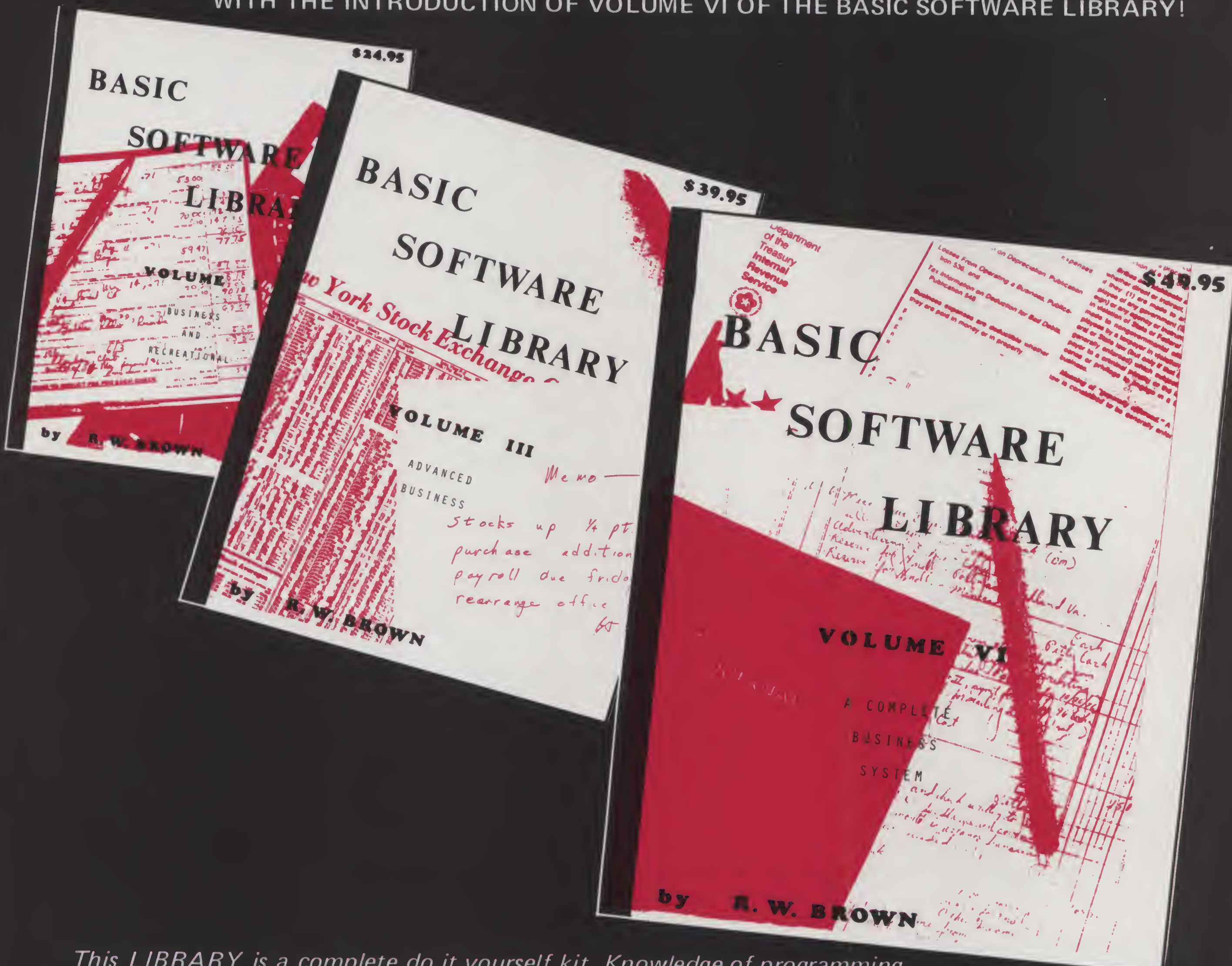

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Many games in the pac may be played with two or more participants, six of them allow the degree of difficulty to be varied, some involve two people with calculators playing against each other. For further information contact Hewlett-Packard, 1501 Page Mill Road, Palo Alto CA 94304.

```
RUN
        I CAN HELP YOU MAKE DECISIONS BY CHOOSING THE
BEST POSSIBILITY FOR YOU OUT OF SEVERAL ALTERNATIVES.
ALL I NEED TO DO IS ORGANIZE INFORMATION YOU ALREADY HAVE.

        WHICH OF THESE BEST DESCRIBES THE TYPE OF
DECISION YOU HAVE TO MAKE?

   1 — CHOOSE AN ITEM FROM SEVERAL ALTERNATIVES
   2 — CHOOSE A COURSE OF ACTION FROM SEVERAL ALTERNATIVES

WHICH TYPE (1 OR 2) DO YOU HAVE TO MAKE? 1

        WHAT TYPE OF ITEM IS IT THAT YOU
NEED TO DECIDE UPON
? CAR

        I WILL NOW NEED A LIST OF EACH CAR
THAT YOU ARE CONSIDERING. PLEASE INPUT THEM ONE AT A
TIME. THE ORDER IS OF NO PARTICULAR IMPORTANCE.

        FIRST, HOW MANY ARE THERE ALTOGETHER? 4

NUMBER 1 PLEASE
? DODGE ASPEN

NUMBER 2 PLEASE
? VOLVO

NUMBER 3 PLEASE
? CHEVY NOVA

NUMBER 4 PLEASE
? ROLLS ROYCE

O.K. THIS IS THE LIST UNDER CONSIDERATION

   1 DODGE ASPEN
   2 VOLVO
   3 CHEVY NOVA
   4 ROLLS ROYCE

        IS THIS CORRECT (YES OR NO)? YES

        NOW, HOW MANY DIFFERENT FACTORS ARE IMPORTANT
TO YOU IN CHOOSING A CAR
? 6

        I NEED A LIST OF EACH OF THESE FACTORS

 FACTOR NUMBER 1
? FUEL ECONOMY

 FACTOR NUMBER 2
? HANDLING EASE AND COMFORT

 FACTOR NUMBER 3
? AESTHETICS

 FACTOR NUMBER 4
? MAINTENANCE

 FACTOR NUMBER 5
? PRICE

 FACTOR NUMBER 6
? SAFETY

        NOW LOOK AT THE FOLLOWING LIST OF FACTORS YOU
HAVE PROVIDED AND DECIDE WHICH IS THE MOST IMPORTANT

   1 FUEL ECONOMY
   2 HANDLING EASE AND COMFORT
   3 AESTHETICS
   4 MAINTENANCE
   5 PRICE
   6 SAFETY

        WHICH FACTOR (BY NUMBER) IS MOST IMPORTANT?
(INPUT 0 IF YOU WISH TO CHANGE THE LIST
? 5

        O.K. SUPPOSE WE HAVE A SCALE OF IMPORTANCE THAT
RANGES FROM 0 TO 10. LET'S SAY PRICE
HAS A VALUE OF 10 SINCE IT IS AT THE TOP OF THE SCALE. ON
THIS SCALE, WHAT VALUE WOULD EACH OF THE OTHER FACTORS
HAVE (DECIMAL NUMBERS ARE O.K.)?

FUEL ECONOMY
? 9
HANDLING EASE AND COMFORT
? 7.5
AESTHETICS
? 4
MAINTENANCE
? 6.5
SAFETY
? 7

        NOW CONSIDER HOW EACH CAR
RATES WITH RESPECT TO EACH OF THE FACTORS. WE WILL
CONSIDER EACH FACTOR SEPARATELY AND THEN RATE EACH
CAR IN TERMS OF THAT FACTOR ONLY.

LET'S CONSIDER DODGE ASPEN TO HAVE A
VALUE OF 10 ON EACH SCALE. THEN EVERY OTHER CAR
WILL BE GIVEN A NUMBER HIGHER OR LOWER THAN 10
ACCORDING TO HOW MUCH BETTER OR WORSE THAN
DODGE ASPEN YOU THINK IT IS.

    CONSIDERING FUEL ECONOMY ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING.

VOLVO
? 11
CHEVY NOVA
? 10
ROLLS ROYCE
? 3

    CONSIDERING HANDLING EASE AND COMFORT ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:

VOLVO
? 9
CHEVY NOVA
? 9
ROLLS ROYCE
? 5.5

    CONSIDERING AESTHETICS ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:

VOLVO
? 11
CHEVY NOVA
? 10
ROLLS ROYCE
? 16

    CONSIDERING MAINTENANCE ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:

VOLVO
? 8.5
CHEVY NOVA
? 13
ROLLS ROYCE
? 5

    CONSIDERING PRICE ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:

VOLVO
? 5
CHEVY NOVA
? 10.5
ROLLS ROYCE
? 2

    CONSIDERING SAFETY ONLY, AND
ASSUMING DODGE ASPEN HAS A VALUE OF 10,
WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:

VOLVO
? 12
CHEVY NOVA
? 10
ROLLS ROYCE
? 13

        WELL, YOUR BEST CHOICE SEEMS TO BE CHEVY NOVA
BUT IT'S PRETTY CLOSE.

        HERE'S THE FINAL LIST WITH CHEVY NOVA
GIVEN A VALUE OF 100 AND THE OTHERS SET ACCORDINGLY

RATING          CAR
 100            CHEVY NOVA
 96.2719        DODGE ASPEN
 83.7868        VOLVO
 53.2279        ROLLS ROYCE
OK
```

Fig. 1. Sample Run.

for the relative importance of each factor are normalized so that they sum to 1.

Now, for each alternative under consideration, the terms are combined as follows: A sum is produced over all the factors. Each term consists of the product of the general importance of that factor and the utility of the alternative under consideration with respect to that factor. Whew! That was quite a mouthful. An example should make it clear.

For Joe, the value for each car consists of the sum of six terms. Consider the Aspen. The first term would be the product of the relative importance of fuel economy times the fuel economy of the Aspen (compared to the other cars). The next term would be the product of the relative importance of handling times the handling value for the Aspen (compared to the other cars). Similarly, terms would be produced for aesthetics, maintenance, price, and safety.

The six terms would then be added to get a value for the Aspen. Similarly, a value for the Volvo, Nova, and Rolls would also be produced.

Now, the list is sorted in order of highest rating. The value of the highest alternative is multipled by a number to give it a value of 100. The values of the other choices are also multiplied by the same number to give them their proper place on the new scale.

More Utility

It is important to emphasize that the utility of an alternative is simply its relative value *to you.*

Suppose you are deciding which of three job offers to accept. One of the important criteria in the decision is the salary of each job. Let's say the three jobs have yearly salaries of $10,000; $15,000; and $20,000. This does not automatically make their relative utilities 10, 15, and 20

```
100 REM    A DECISION MAKER
110 REM    WRITTEN BY PHIL FELDMAN AND TOM RUGG — APRIL 1977
115 CLEAR 500
120 DIM F$(10),L$(10),F(10),M(10,10),V(10),Z(10):PRINT
130 Y$="Y":PRINT"     I CAN HELP YOU MAKE DECISIONS BY CHOOSING THE"
140 PRINT"BEST POSSIBILITY FOR YOU OUT OF SEVERAL ALTERNATIVES."
150 PRINT"ALL I NEED TO DO IS ORGANIZE INFORMATION YOU ALREADY HAVE."
160 PRINT:PRINT"     WHICH OF THESE BEST DESCRIBES THE TYPE OF"
170 PRINT"DECISION YOU HAVE TO MAKE?":PRINT
180 PRINT" 1 — CHOOSE AN ITEM FROM SEVERAL ALTERNATIVES"
190 PRINT" 2 — CHOOSE A COURSE OF ACTION FROM SEVERAL ALTERNATIVES"
200 PRINT:INPUT"WHICH TYPE (1 OR 2) DO YOU HAVE TO MAKE";C
210 IF C<1 OR C>2 THEN 200
220 PRINT:IF C=1 THEN PRINT"     WHAT TYPE OF ITEM IS IT THAT YOU"
230 IF C=1 THEN PRINT"NEED TO DECIDE UPON":INPUT S$
240 IF C=2 THEN S$="COURSE OF ACTION"
250 PRINT:PRINT"     I WILL NOW NEED A LIST OF EACH ";S$
260 PRINT"THAT YOU ARE CONSIDERING. PLEASE INPUT THEM ONE AT A"
270 PRINT"TIME.   THE ORDER IS OF NO PARTICULAR IMPORTANCE."
280 PRINT:INPUT"    FIRST, HOW MANY ARE THERE ALTOGETHER";L0
290 IF L0>= 2 AND L0<= 10 THEN 310
300 GOSUB 890:GOTO 280
310 PRINT:FOR I=1 TO L0:PRINT:PRINT"NUMBER ";I;" PLEASE"
320 INPUT L$(I):NEXT I:PRINT
330 PRINT"O.K.   THIS IS THE LIST UNDER CONSIDERATION":PRINT
340 FOR I=1 TO L0:PRINT I;TAB(5);L$(I):NEXT I:PRINT:GOSUB 900
350 IF B$<>Y$ THEN 250
360 PRINT:PRINT"     NOW, HOW MANY DIFFERENT FACTORS ARE IMPORTANT"
370 PRINT"TO YOU IN CHOOSING A ";S$:INPUT F0
380 IF F0>= 1 AND F0<= 10 THEN 400
390 GOSUB 890:GOTO 360
400 PRINT:PRINT"     I NEED A LIST OF EACH OF THESE FACTORS"
410 FOR I=1 TO F0:PRINT:PRINT" FACTOR NUMBER ";I:INPUT F$(I):NEXT
420 PRINT:PRINT"     NOW LOOK AT THE FOLLOWING LIST OF FACTORS YOU"
430 PRINT"HAVE PROVIDED AND DECIDE WHICH IS THE MOST IMPORTANT"
440 PRINT:FOR I=1 TO F0:PRINT I;TAB(5);F$(I):NEXT
450 PRINT:PRINT"     WHICH FACTOR (BY NUMBER) IS MOST IMPORTANT?"
460 PRINT"(INPUT 0 IF YOU WISH TO CHANGE THE LIST":INPUT F2
470 IF F2=0 THEN 360
480 IF F2<1 OR F2>F0 THEN 450
490 PRINT:PRINT"     O.K.   SUPPOSE WE HAVE A SCALE OF IMPORTANCE THAT"
500 PRINT"RANGES FROM 0 TO 10. LET'S SAY ";F$(F2)
510 PRINT"HAS A VALUE OF 10 SINCE IT IS AT THE TOP OF THE SCALE. ON"
520 PRINT"THIS SCALE, WHAT VALUE WOULD EACH OF THE OTHER FACTORS"
530 PRINT"HAVE (DECIMAL NUMBERS ARE O.K.)?":PRINT:FOR I=1 TO F0
540 IF I=F2 THEN 570
550 PRINT F$(I):INPUT F(I):IF F(I)>= 0 AND F(I)<= 10 THEN 570
560 PRINT"   YOUR INPUT IS NO GOOD, TRY AGAIN":GOTO 550
570 NEXT:F(F2)=10:C=0:FOR I=1 TO F0:C=C+F(I):NEXT:FOR I=1 TO F0
580 F(I)=F(I)/C:NEXT:PRINT:PRINT"   NOW CONSIDER HOW EACH ";S$
590 PRINT"RATES WITH RESPECT TO EACH OF THE FACTORS. WE WILL"
600 PRINT"CONSIDER EACH FACTOR SEPARATELY AND THEN RATE EACH"
610 PRINT S$;" IN TERMS OF THAT FACTOR ONLY.":PRINT
620 PRINT"LET'S CONSIDER ";L$(1);" TO HAVE A"
630 PRINT"VALUE OF 10 ON EACH SCALE. THEN EVERY OTHER ";S$
640 PRINT"WILL BE GIVEN A NUMBER HIGHER OR LOWER THAN 10"
650 PRINT"ACCORDING TO HOW MUCH BETTER OR WORSE THAN"
660 PRINT L$(1);" YOU THINK IT IS.":FOR I=1 TO F0:PRINT
670 PRINT" CONSIDERING ";F$(I);" ONLY, AND"
680 PRINT"ASSUMING ";L$(1);" HAS A VALUE OF 10,"
690 PRINT"WHAT VALUE WOULD YOU GIVE TO EACH OF THE FOLLOWING:"
700 PRINT:FOR J=2 TO L0
710 PRINT L$(J):INPUT M(J,I):IF M(J,I)>= 0 THEN 730
720 PRINT"   C'MON.   NO NEGATIVE NUMBERS.   TRY AGAIN.":GOTO 710
730 NEXT J:PRINT:M(1,I)=10:NEXT I:FOR I=1 TO F0:C=0:FOR J=1 TO L0
740 C=C+M(J,I):NEXT J:FOR J=1 TO L0:M(J,I)=M(J,I)/C:NEXT J:NEXT I
750 FOR J=1 TO L0:V(J)=0:FOR I=1 TO F0:V(J)=V(J)+M(J,I)*F(I)
760 NEXT I:NEXT J:FOR I=1 TO 10:Z(I)=I:NEXT:C=L0-1:FOR J=1 TO L0
770 FOR I=1 TO C:N1=Z(I):N2=Z(I+1):IF V(N1)>V(N2) THEN 790
780 Z(I+1)=N1:Z(I)=N2
790 NEXT I:NEXT J:C1=Z(1):C2=Z(2):C=100/V(C1):FOR J=1 TO L0
800 V(J)=C*V(J):NEXT:PRINT:PRINT:D=V(C1)-V(C2)
810 PRINT"  WELL, YOUR BEST CHOICE SEEMS TO BE ";L$(C1)
820 IF D<10 THEN PRINT"BUT IT'S PRETTY CLOSE."
830 IF D<20 AND D>=10 THEN PRINT"BY A FAIR MARGIN."
840 IF D>= 20 THEN PRINT"BY A GOOD-SIZED MARGIN."
850 PRINT:PRINT"   HERE'S THE FINAL LIST WITH ";L$(C1)
860 PRINT"GIVEN A VALUE OF 100 AND THE OTHERS SET ACCORDINGLY"
870 PRINT:PRINT:PRINT"RATING",S$:FOR J=1 TO L0:C=Z(J)
880 PRINT V(C),L$(C):NEXT:END
890 PRINT"     THE NUMBER MUST BE BETWEEN 2 AND 10":RETURN
900 INPUT"     IS THIS CORRECT (YES OR NO)";A$
910 B$=LEFT$(A$,1):RETURN
```

Fig. 2. Program Listing.

respectively (with respect to salary). For example, you might consider $10,000 almost impossible to live on, $15,000 to be adequate, and $20,000 only slightly better than $15,000. Thus the relative utilities might be 10, 100, and 120. Perhaps, for some obscure tax reason, you might even prefer a lower salary over a higher one. The Volvo, though more expensive than the Aspen, did not cost nearly twice as much. Yet Joe considered the impact of Volvo's extra price enough to give it only half the utility of the Aspen with regard to price.

It is interesting to note that, historically, many different utility functions have been proposed for the relative utility of sums of money. Bernoulli (18th century) thought the relative utility of sums of money varied as the log of the amount. Another famous mathematician, Cramer, suggested that the utility should vary as the square root of the sum.

Of course it's all relative. What is another million to the Rockefellers? What would a million mean to you? The utility of an amount is its relative value *to you.*

What the Program Can Do

The program can help with a wide range of decisions. Here are some recent examples of its use not already mentioned.

Making decisions about upgrading your computer system is a good application. One friend recently compared new memory boards he was considering getting. His relevant factors were price, size, speed, power, and reliability.

Personal decisions are another good use. Another friend was at a crossroads in his life. He was trying to decide whether to get a better job, go back to school, or to marry his girl friend. We are under strict orders not to reveal the results of this application.

How about those sticky business deals we are sometimes offered? Should we say yes, no, or just hold tight for a while? Perhaps profit, friendship, reputation, and integrity are on the line.

Anyhow, the number of uses is unlimited. Just use your imagination and more will come to mind. As long as the consequences of each action can be given a value, the program can be used.

What It Can't Do

There are certain classes of decisions with which this program cannot really help. Decision Theory recognizes four types of decisions. They are: decisions under certainty, decisions under risk, decisions under uncertainty, and decisions under conflict. Let's look quickly at each of them.

Decision under certainty is the type we have been considering. The program was designed to handle this class of problem. Certainty means we can assign a utility function to each alternative under consideration.

The other three types of decisions cannot be handled by the program. They all involve an "outside element."

Decision under risk implies nature will assume a role which cannot be predicted. Consider a farmer who must decide what crop to plant. The success of the crop will depend on the type of weather encountered during the season. Different crops respond differently to different types of weather. Though the farmer can assign a probability of occurrence to each type of weather, he cannot say for sure which type will occur.

Decision under uncertainty is even tougher. Now, the possible outcomes are known but no probability can be assigned to them. Consider a juror who must decide the guilt or innocence of a defendant. The true state (guilt or innocence) may never be known by the juror with certainty, yet he must make his best judgment from the available evidence.

Decision under conflict is entirely different. Here the decision-maker must choose a strategy from available alternatives to try to increase his utility. However, he has an opponent who is also selecting a strategy. The utilities of the opponents are at the expense of each other. When one increases, the other decreases. Consider two candidates for a political office. They each must decide on their campaign strategies and try to win as many of the available votes as possible. The effectiveness of one candidate's strategy will depend on what the other is saying and doing. These kind of decisions are in the realm of game theory.

Decisions under certainty are the most common type of real life decisions. The program presented here can help with any of this type. The other types of decisions all involve an "outside element." It is possible, however, to write programs that can help with these kinds of decisions. Perhaps programs for them will be the subject of a future endeavor.

Getting the Most from the Program

The program can provide very useful results for decisions you must make. It may show an alternative to be unexpectedly good or unexpectedly bad. This is telling you something about the decision that should make you reevaluate it.

As your relevant data improves, try rerunning the program. A new outcome may emerge. Try running a difficult decision you had in the past. Did you actually do what the program said was best? Rerun the decision with the advantage of knowing the consequences of your actual decision and your new updated values. Should you have made another decision?

Sensitivity analyses can be very useful. Suppose you are much more confident of one utility function than another. Run the program several times with different values of the less confident utility function. Do the results change significantly? In this way you can determine which factors are most important in affecting the decision at hand.

But the program's most useful effect is to force you to think about decisions systematically and consistently. Simply producing the utility function requested will afford insights into your problem. Perhaps you will find that desirable blend of emotion and logic in forming your utility functions and making your decisions.

BASICs

The program (Fig. 2) was written in MITS BASIC. String variables and string arrays are used freely. The function LEFT$(A$,1) in line 910 returns a string equal to the first character of the string A$.

Different BASICs have different conventions on the amount of string space allocated by default. If necessary, be sure to request sufficient string space before running the program. With MITS BASIC this is accomplished with the CLEAR statement as used in line 115.

The number of allowed alternatives and factors is 10. This should prove adequate for any practical application you might have.

We checked the program out using MITS Disk Extended 4.0 BASIC. It required about 4K beyond that required for the *BASIC* itself. The program should run easily in a 12K system running with 8K BASIC.

A Final Word

We hope you try out the program. That should be one easy decision. If you find a new application, improvement, or have any questions, feel free to contact us. Now if you'll excuse us, we have to decide what decision to decide next. ■

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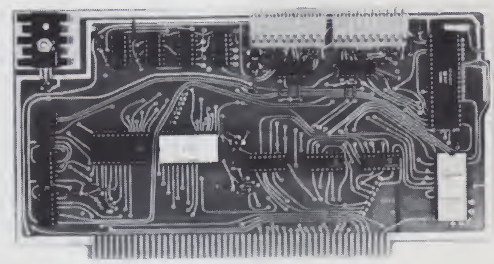

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This is a complete 8080, 8085, or Z80 system controller. It provides the terminal I/O (RS232, 20 mA, or TTL) and the data cartridge I/O, plus the motor controlling parallel I/O latches. One kilobyte of on board ROM provides turn on and go control of your Altair or Imsai. No more bootstrapping. Loads and Dumps memory in hex on the terminal, formats tape cartridge files, has word processing and paper tape routines. Best of all, it has the search routines to locate files and records by means of six, five, and four letter strings. Just type in the file name and the recorder and software do the rest. Can be used in the BiSync (IBM), BiPhase (Phase Encoded) or NRZ modes with suitable recorders and interfaces. $190, wired and tested; $160, kit form.

AUDIO CASSETTE INTERFACE (ACI)
This is the phase encoding board used in the 3M3. Additional components on the board enable you to use audio recorders in the KC standard or the new PE 2400 (2400 baud) systems. Can also be used for Tarbell if you have an 8251 Intel I/O chip. Required if you use an audio cassette with the 2SIO (R) above. $50, wired and tested; $35, kit form.

For 6800 Users: Software programs and I/O board for SWTP are under development. Limited software available now. Ask for 6800 data with $3.00 Documentation package. These programs will provide full software control.

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Inside the Amazing ASR 33

... checking out the most popular terminal

Samuel S. Starr
School Lane, Rose Valley
Rt. 35
Media PA 19063

If you have ever raised the cover of a Model 33 Teletype while it is operating, you might have pulled back involuntarily to avoid the shower of metal parts which seems about to erupt at any moment. Not only does it

keep right on typing, but most of them continue on for years as long as liberally supplied with lubricating oil. Service manuals have lengthy sections devoted to details of lubrication, but the common practice among many experienced service men seems to be to just squirt oil everywhere except on the ribbon.

If Henry Ford put America on wheels then certainly the Model 33 put America, and the world, in communication with computers. Since it was first introduced in 1962, more than 470,000 were produced thru 1976. By the end of this year over a half million of these machines will have been shipped, and this does not include its forerunner, the 5-level Model 32, or the "souped-up" Model 35. Like the VW Beetle, they have been virtually unchanged year after year, apparently on the same principle, that when you know you have something good, leave it alone.

A testimony to the quality of the Model 33 is the fact the ASR (Automatic Send-Receive) 3320, 3JA, the version most common for computer use, currently lists at $1070 new, yet old machines rebuilt by a number of companies, still bring approximately $900.

Some of the Benefits

The Model 33 is supplied in three basic configurations: a receive only (RO), consisting only of a printer unit; a keyboard send-receive (KSR), which adds a keyboard to the printer: and an automatic send-receive (ASR), which adds a paper tape reader and punch. It is the latter version which is of the most interest to the small computer hobbyist and to many large commercial users as well. Hard copy is a must for anyone whose computer ambitions extend beyond playing games, and magnetic storage media simply lack the practicality of paper tape for the vast majority of small computer users. Paper tape operations with the Teletype are slow, to be sure, but when faced with the fact that most users have little need for high speed input or output, and the cost of a high speed reader-punch, it is not difficult to live with ten characters per second.

High cost of maintenance has often been stated as a drawback to personal ownership of a Model 33, but those making this statement have probably not studied the technical manuals supplied by Teletype. These manuals are models of what technical manuals should be and are so detailed and illustrated that most users can handle a major part of maintenance themselves. They are truly incredible documents. For example, a modern automobile has vastly more complicated wiring than a Teletype, yet a car wiring diagram usually covers one page of a shop manual. The Model 33 wiring diagram (Part No. VDP-0316, at $4.95 plus freight) consists of thirty-five 11" x 16" sheets. With such documentation almost anyone can soon become an expert. The mechanical side is equally well covered by three well filled loose leaf books, one for general operation, one for adjustments, and one for replacement parts. If any small screw, nut, or spring should fall from a Teletype, you can be certain to find it illustrated, numbered, and fully described.

The Model 33 is compatible with virtually all small computers made throughout the world, probably because the computer manufacturers realize that their product must be compatible, rather than the other way around. Connections to a computer are frequently as simple as connecting four wires, two for input and two for output, from the computer interface to a terminal strip at the back of the Teletype. The same connections are also available at a plug just above the terminal strip. If the Teletype has an automatic tape reader (Version 5JA), these four wires are all that is required, the reader being started and stopped under program control by simply transmitting the proper ASCII character, usually DC-1 (021 in 7-bit ASCII code) to start the reader and DC-3 (ASCII 023) to stop the reader.

Some manufacturers of small computers do not use this method of reader control, but instead use the manual reader (Version 3JA) with an added relay circuit, wired with two extra wires to their interface. The automatic reader (5JA) will work with their computers, but will not respond to their software or firmware. A standard manual reader Teletype is easily converted to their mode of operation by installation of a small printed circuit relay board. These boards have recently been quoted at prices ranging from $50 by a used teletypewriter dealer to $150 by a large and well-known computer manufacturer. Examination of this board, along with a catalog from an electronics supply house, reveals that the total material costs are approximately $4.29 in production quantities.

The Theory Behind the Clankety-Clunk

The basic operation of the Model 33 consists of sending or receiving a series of current pulses, a logic 1 being represented by a flow of current and a logic 0 by no flow. The current levels are 20 or 60 mA, the 20 mA level being most common for computer use. This option, as well as a choice between half duplex or full duplex mode of operation, can be implemented in a few minutes with only a screwdriver. Full duplex, meaning the ability to transmit and receive simultaneously, is the normal computer mode. Factory wiring is for 60 mA current loop and half duplex, consequently the changes must be made on new machines.

Fig. 1 illustrates the

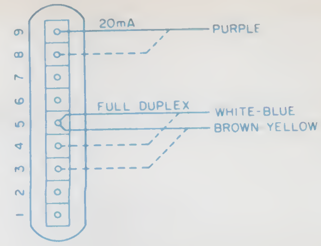

Fig. 1.

changes required to convert from the factory configuration to 20 mA current loop and full duplex.

Data transmission to and from the Teletype is a serial stream of current pulses at a 110 baud rate. Each character transmitted consists of eleven pulses, or more correctly, eleven time units defined in the send mode by the mechanical speed of the distributor rotor and in the receive mode by the clocking in the computer interface. The computer interface, therefore, must be capable of sending pulses at a 110 baud rate. With eleven pulses per character (8 data bits plus one start and two stop bits) this results in a rate of ten characters per second. The eight data bits, in the case of keyboard operation, are a seven-bit ASCII code and an even parity bit. (Don't forget the parity *bit in programming* ASCII masks.) The tape reader transmits whatever is on the eight levels of the tape, regardless of whether it is in ASCII code, binary, or just plain holes.

Transmission of a character starts with a parallel presentation of the eight data bits to the data contacts on the distributor disk. It is a parallel operation because all eight feeler pins in the reader rise at the same time, and the stroke of a key sets all of the code bars at the same time. Transmission in parallel would be faster, but would require a separate line for each bit, cumbersome for a computer and impossible in the case of a telephone line. When the code is ready at the distributor contacts, the distributor rotor makes one

Terminal Strip Contact	No. 2 Connector Pin Number
3	5
4	6
6	7
7	8

Example 1.

revolution, wiping a carbon brush across the ten contacts (a *start* segment and eight *data* segments of equal length, and a *stop* segment of double length, for a total of eleven time units). Depending upon the code presented to the data segments, each time interval is either *marking*, meaning that current is flowing or logical 1, or *spacing*, meaning no current flow or logical 0. With this system the importance of the baud rate setting of the interface becomes obvious. At any setting other that approximately 110 baud, the stream of pulses becomes jibberish.

Receiving functions of the Teletype are largely independent of the sending functions, which makes full duplex operation possible. The stream of serial pulses arrives at the selector magnet driver that drives selector cams, which set the desired ASCII code in a series of code bars. The position of these bars determines how the typewheel will be set, vertically and rotationally. When set, a hammer strikes the typewheel driving it forward into the ribbon and paper.

ASCII code is not just one of a number of codes that a Teletype can receive, but is basic in the entire design of the machine, even to the design of the typewheel. For example, if the no. 4 pulse of the seven-bit ASCII code is marking (logic 1), the typewheel will turn counterclockwise from its null position to find the desired character, and if it is spacing (logic 0), it will turn clockwise and find the desired character on the other half of the typewheel. Pulses 1, 2, and 3 determine how far the typewheel should rotate, (there are eight characters around half of the wheel) and pulses no. 5 and 7 determine which of the four vertical levels of the typewheel will be selected. If pulses no. 6 and 7 are spacing, no selection is made, which means that the code was for a nonprinting function. A check of the ASCII code will reveal that all nonprinting functions have a code below 040, space, 040, being considered a printing function.

Buyer's Guide

The hobbyist who can locate a used ASR-33 in good mechanical condition can be reasonably sure that it can be interfaced to his computer, usually at no additional cost and very little work. The first check to be made is whether it is equipped for current loop operation. This can be determined by removing the cover from the machine and examining the selector magnet driver, a printed circuit board mounted at the right side toward the rear in the call control unit. The board should be labelled, ''.020A .060A NEU 181821''. The side of this board that can be seen if only the small cover over the call control unit is removed will show only the bare board number, 181823.

Depending upon the provenence of the machine, there is a fair probability that it will already be in the 20 mA and full duplex configuration, but these options can be checked.

The 20 mA current loop mode: Check the large flat resistor mounted on the base of the call control unit, about in the center of the area. The four contacts extending toward the rear of the machine are numbered from right to left (looking from the operators position). If the blue wire is on contact no. 3 and contact no. 4 is vacant, slip the wire off no. 3 and push it onto no. 4. Remove the fiber cover from the terminal strip located at the lower rear of the call control unit. Several of the 15-pin plugs can be removed for easier access to the terminal strip. Viewed from the rear, the nine contacts on the strip are numbered from left to right. If the purple wire is on contact no. 8, move it to contact no. 9.

Half or full duplex mode: This requires two checks on the same terminal strip as above. If the brown and yellow wire is on contact no. 3, move it to contact no. 5. If this move was necessary, a white and blue wire will be found on contact no. 4. Move it also to contact no. 5. This completes the checking, or conversion, for 20 mA and full duplex operation.

The signal leads from the computer interface are also connected to this terminal strip. The input signal to the Teletype (printer-punch) will go to contact no. 6 for the negative line and to contact no. 7 for the positive line. Output from the Teletype (keyboard-reader) which is not polarity sensitive, will go to contacts no. 3 and 4.

If a plug-in connection is desired, rather than using the terminal strip, the 15-pin connector no. 2, in the battery of eight located over the terminal strip, is wired in parallel as shown in Example 1.

Programmed control of the tape reader is possibly the only area where some difficulty, and perhaps a small expense, might arise. If a Teletype is acquired equipped with an automatic tape reader, the reader switch should have four labelled positions, *auto*, *start*, *stop*, and *free*, instead of the usual three positions. Also, the reader power pack, usually located in the stand, will have a relay mounted on the circuit board of the power pack. Some hobbyists might prefer to leave it alone, controlling the reader by programmed transmission of DC1 and DC3 as mentioned before. If the hobbyist is concerned only with controlling the reader via his own programming, he can simply program for the automatic reader; but when using other software, or firmware, troubles could arise. For computer systems that use two extra wires from the interface for reader control, the modified manual reader is probably easier to implement for most users, than making both mechanical and electrical changes on the automatic reader. Installation of an additional relay is required in either case, since the existing relay in the automatic reader is not designed for the signal level of most computers, but operates on 48 volts ac.

Many ASR-33 machines will be equipped with *function contacts* which provide a convenient means of program control of external equipment. These switches, located just behind the typing unit, are single pole, double throw, momentary contact, and are rated at 115 volts ac or dc at 100 mA. With the addition of an inexpensive DPDT relay with a coil drawing less than 100 mA, almost anything can be turned on or off under program control by simply transmitting the appropriate ASCII code, such as 004 (EOT), 005 (ENQ), 013 (VT), 021 (DC1), or 023 (DC3). If the automatic tape reader feature is being used, DC1 and DC3 will not be available for other use.

Parting Points

In summary, a hobbyist who can find a good ASR-33 at a price he can afford to pay should not *settle* for anything less. Particularly when a teletypewriter such as the Digital Equipment Corporation LA36, although operating at three times the printing speed, has no paper tape input or output and costs more than twice as much as a new ASR-33. ■

Note: The word *teletypewriter* is a generic term meaning any communications typewriter, while *Teletype* is a copyrighted name owned by Teletype Corporation.

Kenny Winograd
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Seven Greenbriar Dr.
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Try Computer Composition

... Bach never had it so good

If you've ever had the desire to make that computer of yours play music, then this is for you! Ken's article describes a circuit which he designed and built (and wants to share with you) which uses only eight ICs . . . and costs less than $25! That's two sentences and two exclamation marks so far. If I continue describing the article . . . and the comfortable writing style . . . and the thorough coverage of the subject . . . and the complete construction plans . . . there will be a lot more! — John.

Are you sorry you never learned how to play the piano? Don't fret, now you can teach your microcomputer to play tunes you couldn't play in twenty years.

This article will describe the theory (hardware and software), construction and operation of a simple computer music peripheral (for lack of a better name).

The music circuit, upon receipt of a 7 (or 8) bit word from your microcomputer, will output a specified note. The output is suitably conditioned to either feed further synthesis modules or feed the auxiliary input of your home stereo set. The 7 bits can specify any note in an eight octave range, i.e., one of 96 possible notes. That's even more notes than a piano. Note that the circuit itself generates the proper frequency (pitch), not the microcomputer; so the needed software is correspondingly simpler. The circuit tuning, automatically and without any calibration, is equally tempered.

The microcomputer is just responsible for timing the transferal of data bytes (notes) from memory to a specified output port. The music circuit does the rest, including the conversion of the microcomputer's TTL output levels to system compatible levels. The output port should be an 8-bit parallel latched output port. No microcomputer should be without one.

The required software is very simple. I've included, in addition to program listings in 8080A-based assembly language, a flowchart to ease the rewriting of the program into other languages if desired.

Now let's get started.

Circuit Operation

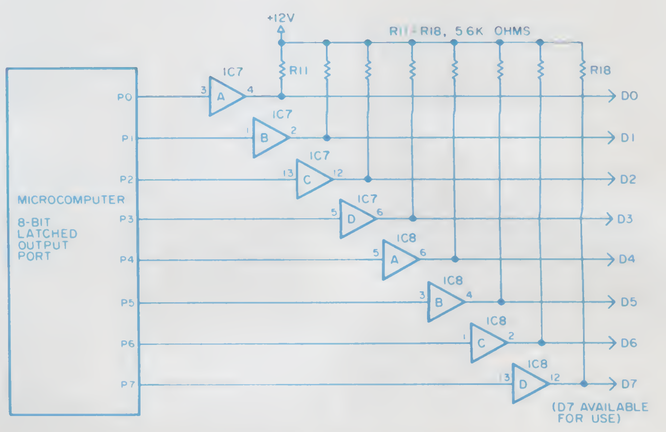
I used an 8080A-based microcomputer (an E&L MMD-1) with this music circuit. The microcomputer output port bits are at a TTL level. The music circuit, though, is mostly a 12 volt CMOS system, so conversion (translation) of voltage levels is required. This is accomplished by IC7, IC8 and R11-R18. IC7 and IC8 are regular TTL 7417 noninverting open-collector buffers (I've just said a mouthful, I know). Referring to Fig. 1, if bit zero of the microcomputer's selected output port (PO) is a logic zero, this pulls the output of IC7-A low to almost zero volts which is fine. If, on the other hand, bit zero (PO) is a logic 1 (about 3 volts for TTL), this will drive the output of IC7-A to an open circuit. But with pull-up resistor R11, which is connected to positive 12 volts, the output, D0, will go to just about 12 volts which is perfect. Note that IC7 and IC8 are the only chips that are powered by positive 5 volts. It is only through the pull-up resistors that a positive 12 volt output can be had for a logic one input. The D0-D6 lines will be used as control signals for the music circuit. P7 (and D7) are not directly needed, but may be used as discussed later.

PC board. Only 8 ICs and less than $25.

Referring to Fig. 2, the main schematic, inverters IC1-A, B, and C are used to form a free-running, high-frequency oscillator. The frequency of the oscillator can be adjusted with potentiometer R3 if you'd like to tune this circuit to another instrument.

The oscillator delivers a source of pulses (a squarewave) to the input of a 7-stage ripple counter, IC2 pin 1. A 7-stage ripple counter sounds more complex than it really is. Try to think about it like this: If you input a frequency that corresponds to, say, an A-sharp note, the Q1 output will be an A-sharp one octave lower in pitch; the Q2 output will be an A-sharp two octaves lower in pitch and so on.

These seven outputs



IC7, IC8 — Noninverting Open Collector Buffer
pin 7 — ground
pin 14 — +5 volts
pins 8, 10 — no connection

Fig. 1. The 5 volt TTL to 12 volt CMOS voltage level conversion schematic.

(Q1-Q7) of octave related frequencies and the oscillator input frequency itself are all input to the data selector chip IC3, which works as follows: One of the eight inputs X0-X7 is selected to appear on the output, pin 14. The input selected to go to the output depends on the 3-bit binary code applied to pins 13, 12, and 11. This code is really signals D6, D5 and D4 which is part of the microcomputer's output word after level conversion (see Fig. 3).

The selected output from IC3 feeds the clock input of IC4, where we get to the real heart of the circuit. IC4 is called a top-octave generator. It operates as follows: Input a very high frequency to the clock input, and you get out simultaneously all twelve notes of an octave.

Now you should begin to see what this music circuit is all about. We start with a suitably high frequency (IC1), make simultaneously available the lower octave related frequencies (IC2), select one of these frequencies (IC3), and generate a whole octave of equally tempered notes (IC4). But (and there is always a but) we're not through yet. We have still to select which note of the octave we want. To do this we utilize the same trick we used to select the desired octave and go to more data selector chips. We need two since there are twelve notes in an octave but only eight inputs on a 4512 data selector chip (IC3, 5, and 6).

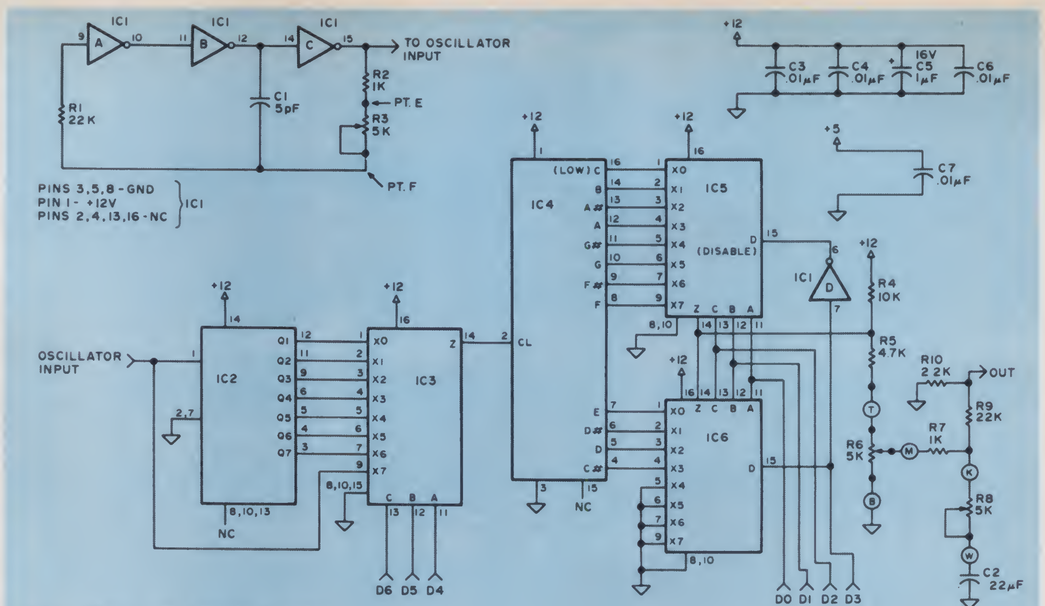
The data selector chips have a feature that was not needed for IC3, but will be needed by IC5 and IC6. This feature is a 3-state output. The three states of the output are high and low (like normal) and a high-impedance state. The high impedance state of the output is such that for all practical purposes, the output can be made to disappear, to look like it's not even connected. This means we can short the outputs of both chips (points Z) as long as only one chip is on at one time. The high-impedance state of IC5 or IC6 can be had by putting a logic 1 onto pin 15. Since only one chip (IC5 or IC6) can be on at a time, the circuitry must reflect this fact. Thus, I've added a leftover inverter from IC1 (IC1-D) to the D3 signal. Now if IC5 is on, IC6 must be off and vice versa.

So now we're almost there. By selecting either IC5 or IC6 through the use of D3, we can use D0, D1, and D2 to select which note we want to output. The code works the same way as the code worked for IC3 (see Fig. 3).

The shorted Z note outputs are then brought out to a point that is halfway between the positive supply and ground (the junction of R4 and R5) to eliminate any popping in the output from a DC offset. I've also added a volume control, R6, and a simple tone control, R8, along with some attenuation (R9 and R10) to enable the output to be connected to an auxiliary input of a stereo system.

Capacitors C3 through C7 are bypass capacitors to help shunt noise voltages to ground.

A block diagram may help clear up the basic idea and flow of the whole circuit (see Fig. 4).



IC1 — 4049, Hex Inverter/Buffer
IC2 — 4024, 7-Stage Ripple Counter
IC3, 5, 6 — 4512, 8-Channel Data Selector
IC4 — AMI/MOSTEK 50240 — Top Octave Divider

Fig. 2. Main schematic.

	D7	D6	D5	D4	D3	D2	D1	D0
octave 8	X	1	1	1				
octave 7	X	0	0	0				
octave 6	X	0	0	1				
octave 5	X	0	1	0				
octave 4	X	0	1	1				
octave 3	X	1	0	0				
octave 2	X	1	0	1				
octave 1	X	1	1	0				
note C	X				1	0	0	0
note C #	X				0	0	1	1
note D	X				0	0	1	0
note D #	X				0	0	0	1
note E	X				0	0	0	0
note F	X				1	1	1	1
note F #	X				1	1	1	0
note G	X				1	1	0	1
note G #	X				1	1	0	0
note A	X				1	0	1	1
note A #	X				1	0	1	0
note B	X				1	0	0	1
rest	X	X	X	X	0	1	1	1
rest	X	X	X	X	0	1	1	0
rest	X	X	X	X	0	1	0	1
rest	X	X	X	X	0	1	0	0
	Available	Octave Select			Note Select			

Example: D # in octave 5 would be — X0100001
X represents a *don't care* state

Fig. 3. Note data word table.

Power Supply Requirements

The power supply requirements are not very large at all. Let's consider the worst

case current. Even though much of this system is CMOS, which generally is not at all power hungry, more current than normal is needed at the higher frequencies we're dealing with (especially IC1). So worst case current occurs when tuning pot R3 is set for the highest frequency possible. Also, whenever the microcomputer's output word contains zeros, this grounds the corresponding output of the 7417 level converting buffers, forcing about 2 mA through its pull-up resistor. All zeros input (which corresponds to the note E in octave 7) and tuning pot set high, then, constitutes the time when maximum current is required. The unit I built drew just under 70 mA at positive 12 volts dc. The positive 5 volt supply must be able to deliver about 50 mA, which is 25 mA per 7417 chip.

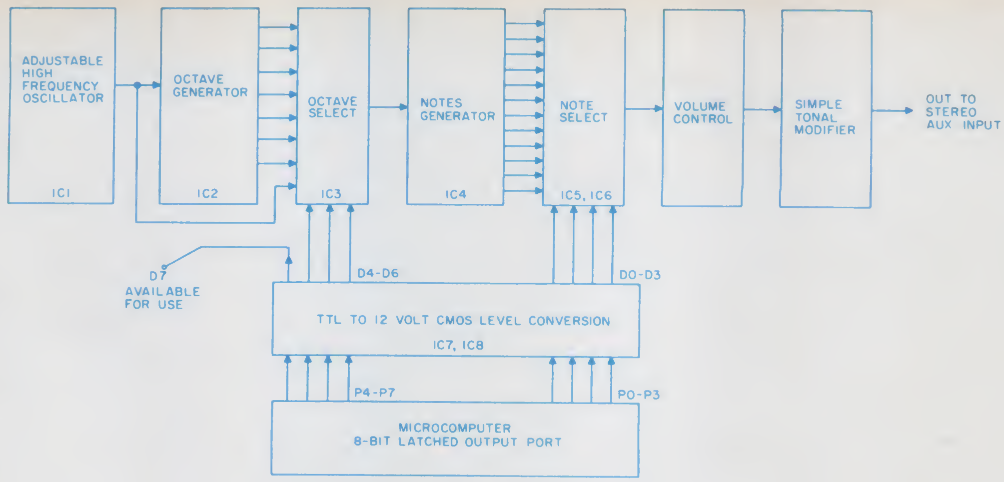


Fig. 4. Block diagram of computer music circuit.

Software

The software needed to run this circuit is very elementary. I will first take you through a simple program that will play a piece that you compose, and then I'll mention ways for you to modify the program, giving you added control and flexibility. The program, as always, can be as simple or as complex as you like.

type of note	binary code	octal	decimal	hex
whole note	10000000	200	128	80
half note	01000000	100	64	40
quarter note	00100000	040	32	20
1/8 note	00010000	020	16	10
1/16 note	00001000	010	8	08
1/32 note	00000100	004	4	04
1/64 note	00000010	002	2	02
1/128 note	00000001	001	1	01

Fig. 5. Duration data word representation.

To work effectively this music circuit just needs a sequence of properly timed output words determining which note to be played and when. To do this the computer must retrieve from memory a code word for which note to play, output it (play it), then read the next data word to determine how long to play the note. When the note has been played for the correct amount of time, the computer then determines if there's another note to be played. If there is, it starts the same cycle all over again. If not, it halts. What could be simpler?

Now, what about timing? We need a convenient way of representing note values, i.e., quarter notes, half notes, etc. This part is easy. Consider the following property of binary numbers: 0100 is twice the value of 0010, which, in turn, is twice the value of 0001. All we did is shift the 1 bit left or right to double or halve the value of the number. So let's call the data duration word 10000000 a whole note, and 01000000 a half note, 00100000 a quarter note, and on to 00000001, which would be a one hundred and twenty-eighth note, very fast (see Fig. 5).

In order to get the proper timing, a base must be established. I used a 10 millisecond delay as a base. The data duration word, then, will determine how many 10 millisecond delays should be used for the note. The basic 10 millisecond delay is a subroutine that is called repeatedly until the proper amount of time has elapsed.

Now refer to Fig. 6 which is a flowchart for this simple program. Starting at the top, first set the Stack Pointer, if this is not done automatically for you. If you do set it, be

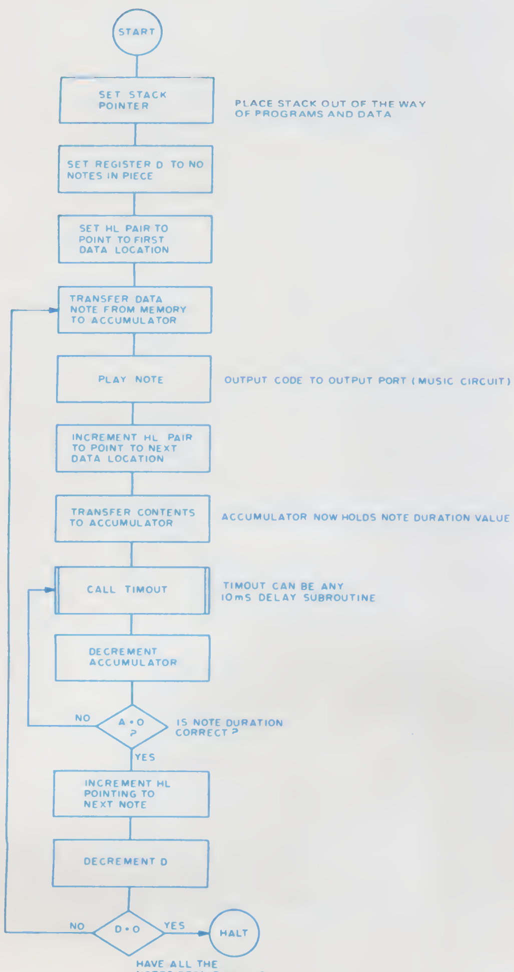


Fig. 6. Flowchart of main program.

sure to set it out of the way of the main program, subroutine, or data locations. Set the D register (or DE register pair for compositions longer than 256 notes) to the number of notes in the piece to be played. Then, set the HL register pair with the address of the first data location in memory. Note that if location 100 is the first note in memory, all further even numbered locations in memory are also note codes. All further odd numbered locations contain note duration values.

Now that HL is *pointing* to the first note, transfer the contents of the location that HL points to, into the accumulator. Now, output the accumulator to the specified port, i.e., the music circuit, playing the note.

Increment the HL register pair so it now points to the corresponding timing value for the note being played. Transfer this value to the accumulator. Now we call the subroutine Time Out (TMOUT) which does nothing except delay further activity for about 10 milliseconds. TMOUT does not affect any registers or flags. After the first delay, the accumulator, which holds the duration value, is decremented and then tested to see if the proper amount of programmed duration has elapsed. If not, jump to the location that calls the delay subroutine again. When the proper delay has arrived, increment the HL register pair to *point* to the next data word, a note word. But before playing it, decrement and test the D register to check if all the notes have been played yet. If so, halt; if not, then jump to the point where the new note code is transferred through to the music circuit. Fig. 7 shows the program listing in 8080A-based assembly language.

The TMOUT delay subroutine can be any subroutine that gives a delay about 10 milliseconds. I used a TMOUT subroutine (see Fig.

Symbolic Location	Instruction or Data	Remarks
BEGIN	LXI SP, out-of-the-way	
	—	
	—	
	MVI D, #of notes in piece	
	—	
	LXI HL, first data address	
	—	
	—	
NOTE	MOV A,M	
	OUT XXX (whatever port you use)	
	—	
	INX HL	
	MOV A,M	see flowchart for
DELAY	CALL TMOUT	main program remarks
	—	
	—	
	DCR A	
	JNZ DELAY	
	—	
	—	
	INX HL	
	DCR D	
	JNZ NOTE	
	—	
	—	
	HLT	
TMOUT	PUSH PSW	save flags
	PUSH DE	save register in use
	LXI DE, 0126(hex)	load D&E with value
	26	to be decremented
	01	
MORE	DCX DE	jump in this loop
	MOV A,D	until D&E are both
	ORA E	zero
	JNZ MORE	
	—	
	—	
	POP DE	restore registers in use
	POP PSW	restore flags
	RET	

Fig. 7. Main program and subroutine listing — 8080A assembly language.

7) that is part of the executive (or monitor) that came with the microcomputer I am using, an E&L MMD-1. The delay is generated by looping repeatedly through a number of instructions until a certain count is reached. The instruction cycle times of your computer will no doubt be different than mine. For reference, a DCR D instruction on the E&L MMD-1 takes a total of 6.65 microseconds which is 1.33 microseconds per state. If it is different, this should cause you no worries. Maybe your half note will almost equal my quarter note or whole note, it doesn't matter. Relative durations will still be exact.

As I mentioned previously, the program we just ran through is a simple one. To extend the usefulness of this circuit, you may wish to set up program loops to repeat the piece automatically, endlessly, or a set number of times and then maybe even branch to a new section of data.

Another idea is to add an additional timing loop just outside the 10 millisecond delay loop. With this addition, you can change the tempo of the piece without having to change the timing values of the notes in every other data location. We'll call this new loop the tempo loop. See Fig. 8 for an assembly language listing of the main program with this simple modification included. Basically, what the loop does is this: After the 10 millisecond delay subroutine has been called a sufficient number of times to equal the type of note programmed (say, an eighth note), the delay is started again from scratch until the value in the tempo register (B) equals zero. This happens for every note played. So, if we initially load a value of 3 in the tempo register, the delay will be 3 times as long as usual. Loading a value of 5 would slow the piece down considerably. If you decide to use this modification, you should remember to decrease the basic time of 10 milliseconds so that you can get a more useful way to adjust tempo. In other words, if you used a 10 millisecond delay as a base, changing the tempo register from a 2 to a 3 represents a considerable change . . . loading a 255 (eight bits of all ones) would be ridiculously slow. So in order to use the full 1-255 range of tempo settings, the TMOUT delay should be decreased. For this modification, a basic time delay of about 0.1 milliseconds should suffice.

Composing and Coding

Composing and coding is very simple. Well, the coding is simple anyway. Each note played requires two data words. The first word indicates by code (Fig. 3) which of 96 possible notes is to be played. The next word indicates how long the note should be played (Fig. 5). That's really all there is to it. With 1K (1024) bytes of memory, a composition of 512 notes can be played, not counting program space. Fig. 9 shows a data listing for playing in ascending order all the notes in the key of C in octave 4 as sixteenth notes. This is obviously a trivial example, so you code what you would like to hear *performed*.

If you program your microcomputer with groups of switches, you're all set; just follow the note code . . . D7 is immaterial. Of course if you program your microcomputer through a hex or octal keyboard, you will have to decide what D7, the eighth bit, should be set to in order to get a proper note code. For instance, the note code for C-sharp in octave 2 is X1010011. If you go the hex or octal route, just decide beforehand whether D7 is a

Symbolic Location	Instruction or Data	Remarks
BEGIN	LXI SP, out-of-the-way	
	—	
	—	
	MVI D, # of notes in piece	
	—	
	LXI HL, first data address	
	—	
	—	
	MVI B, tempo number	load relative tempo #
	—	into register B
NOTE	MOV A,M	
	OUT XXX (whatever port you use)	
	—	
	INX HL	
TEMPO	MOV A,M	
DELAY	CALL TMOUT	
	—	
	—	
	DCR A	
	JNZ DELAY	
	—	
	—	
	DCR B	decrement tempo register
	JNZ TEMPO	if not zero, continue delay
	—	
	—	
	INX HL	
	DCR D	
	JNZ NOTE	
	—	
	—	
	HLT	

Fig. 8. Main program with tempo modification listing.

one or a zero. Now, if you decide to set D7 at one, then the code is 11010011. This, in its present form, can be given a hex or octal coding for keyboard entry.

To facilitate coding, I'd make up another table based on Fig. 3, but incorporating bit D7 so your table can be in hex or octal rather than groups of ones and zeros.

Construction

I have included a single-sided printed circuit layout (Fig. 10) to ease construction headaches. A component placement diagram is also included (Fig. 11). If you go this route, you should have no problems.

Since some of the chips are CMOS and are thus static susceptible, I used IC sockets. ICs 1, 2, 3, 5 and 6 are CMOS; ICs 7 and 8 are regular TTL and IC4 is P-channel MOS. Also, be sure to note that not all chips point in the same direction (Fig. 11).

IC holes should be drilled using a #66 drill. Other holes could be drilled with a #60 drill, or one slightly larger. All resistors are noncritical (10% tolerance is OK). Half or quarter Watt resistors can be used. C2 is a mylar capacitor. C5 is an electrolytic capacitor. C1, C3, C4, C6 and C7 are disk capacitors.

Rather than routing printed circuit lines through IC leads which makes home soldering difficult, I decided to go with jumpers instead. Thus, be sure to include the nine jumpers when components are installed (Fig. 11). A few of the jumper wires are close together, so for these, at least, be sure to use insulated wires.

All parts which the probable exception of IC4 (50240) can be purchased from most surplus houses. The 50240, last I heard, can be purchased from Paia Electronics, PO Box 14359, Oklahoma City OK 73114. They charge $12.50 plus $1.00 shipping for what they call EK-1, a top octave experimenter kit that includes the 50240. If you can find a 50241 chip, all the better. The 50241 is a pin for pin replacement for the 50240, though it has a 30% output duty cycle rather than a 50% duty cycle. This would mean more harmonics present in the note output. This feature could really be helpful, especially if this music circuit will be feeding additional synthesis modules.

Testing and Calibration

The first thing to do is to ensure that all system components (microcomputer, supplies, music circuit, stereo set) share a common ground. For a first test, just connect the output to an auxiliary input of a stereo set, center the tuning pot, and apply power supply voltages. You should hear a tone. If, at this time, you left the P0 through P6 inputs unconnected, D0 through D6 would go high (since a TTL input left hanging appears high, forcing the output of the level converters high). This, according to Fig. 3, corresponds to the note F in octave 8, a very high pitch.

I can only think of one section that may need to be calibrated, and that is the input oscillator (IC1 and associated components). In order to get a full 8 octave range with this music circuit, the output frequency of the oscillator should exactly be 2.00024 MHz. Without the aid of a crystal or other suitable references, the exact range of tuning may be somewhat different for every oscillator assembled. I listed component values that worked well for me. If the range of yours is unsatisfactory, try adjusting the value of capacitor C1. If you have access to a frequency counter, all the better.

The tonal modifier portion of the circuit (controlled by R8) is ultra-simple and just included for the convenience of those who intend using this circuit by itself. If the output of this circuit is used to feed further modifiers of one sort or another, you may even want to disable this portion of the circuit.

memory location	contents	remarks
AA00	X0111000	note C4
AA01	00001000	1/16 note duration
AA02	X0110010	note D4
AA03	00001000	1/16
AA04	X0110000	note E4
AA05	00001000	1/16
AA06	X0111111	note F4
AA07	00001000	1/16
AA08	X0111101	note G4
AA09	00001000	1/16
AA0A	X0111011	note A4
AA0B	00001000	1/16
AA0C	X0111001	note B4
AA0D	00001000	1/16
AA0E	X0101000	note C5
AA0F	00001000	1/16

Fig. 9. Example of data list: C scale, octave 4, 1/16 notes.

Further Thoughts

As mentioned previously, this music circuit only requires 7-bit words, but, of course, most home computers utilize 8-bit words. Why not put that eighth bit, P7 that is, to use?

I have included provisions on the circuit PC pattern for the TTL to 12 volt CMOS conversion of P7 into D7, if you need it. This bit could be used for computer control of, say, a filter or other tonal modifier. Of course, since it's only one bit, it's got to be a 2-state device, unless you get fancy.

Readers who already own other synthesizer equipment will realize the need for gate and/or trigger voltages with each note to control other processing modules such as envelope generators. So why not set D7 to a logic 1 each time a note is played and generate an automatic gate voltage. Don't forget though that if you decide to do this, you must be sure to reset D7 to a zero after each note is played, or else the gate will always be on. This should be done by always having D7 a logic 1 and then add a couple of steps to the program to reset D7 to a logic 0 before the next note is played.

Also, remember that the microcomputer is so fast that if you program two notes of the same pitch right next to each other, they'll sound like one note of longer duration unless a small delay or pause is added between notes, a couple milliseconds at most. The delay could be added in the software main program, in which case you'd get the short delay between all notes; or you can simply add the delay only as required by inserting a *rest note* of short duration. See Fig. 3 for the code for a musical rest, i.e., silence code.

Another thought: Why not build two of these music circuits and have the capability to program *two hands* of music? How about that? A computer will sequence through a J.S. Bach two part invention. If you build two of these circuits, you would probably want to have both main oscillators on each board to be at the same frequency. With two tuning pots, you could certainly do it, but you may wish to build an outboard oscillator (crystal, perhaps) whose output goes to both boards. Then, of course, only one tuning pot would be necessary. The software must then be changed so that two output ports will be used to output sequenced tone codes, one for each board. Memory requirements would correspondingly increase, from two words per note change to three words per note change. If you go to an outboard oscillator, remember that one of the six inverters on IC1 is used in another part of the circuit. IC1 cannot just be haphazardly removed from the board. IC1-D must still be used, the other inputs must be properly tied off to ground or plus 12 volts.

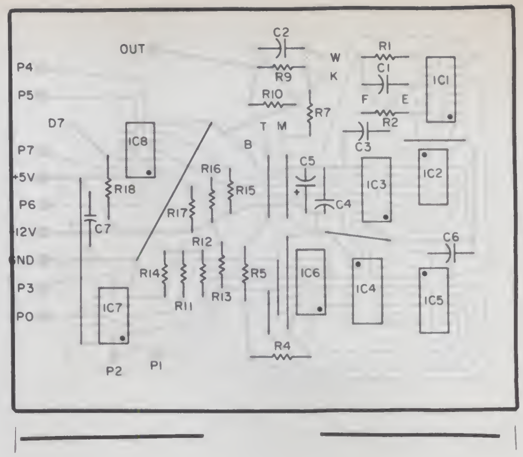


Fig. 11. Component placement diagram.

One last thought: Try using either random tone codes or random tone duration values or even both and listen to the result. This can be done either through main program modifications (random number generators, etc.) or by having the program read data from the locations of another program. That should at least be pseudorandom.

That's all for now. Have fun. ■

An etched and drilled PC board for building the music generator is available from the author for $10. Send check or money order for next-day shipment.

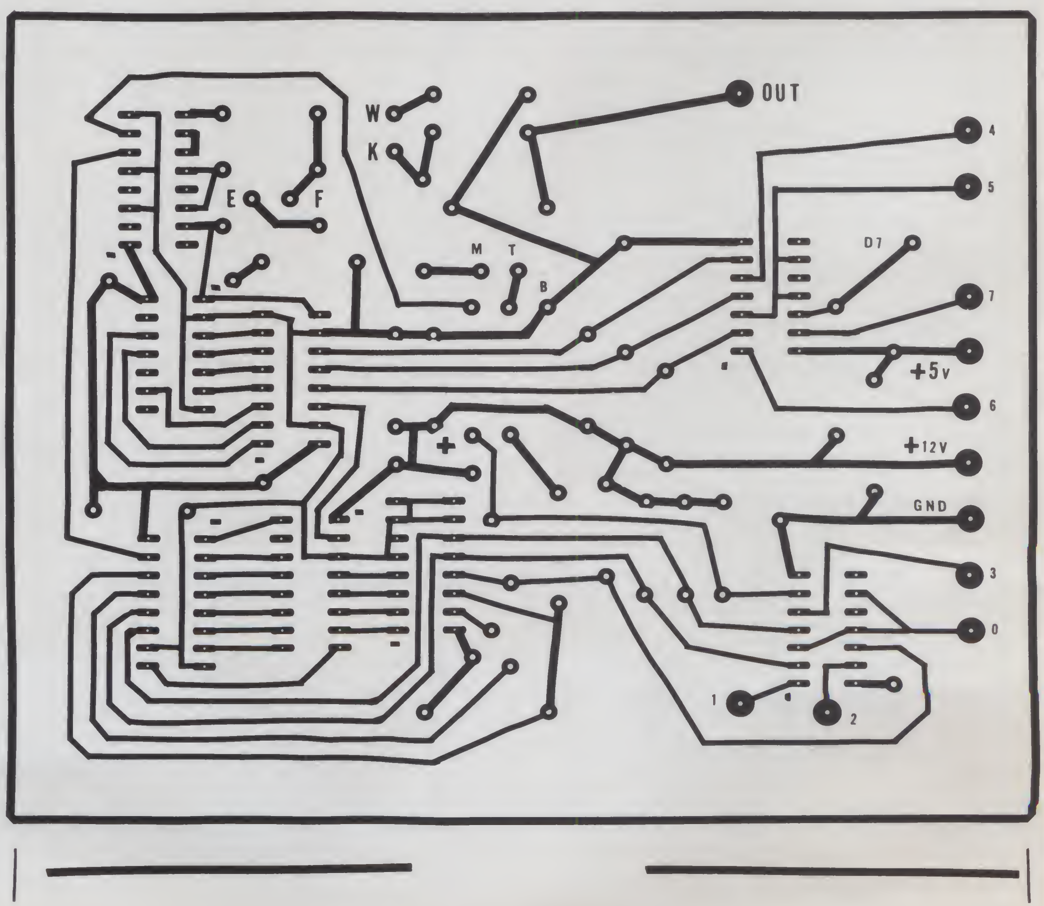


Fig. 10. Printed circuit layout (full size).

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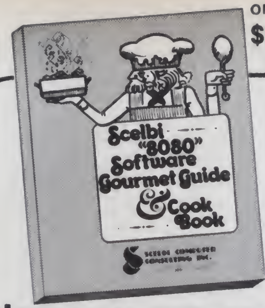

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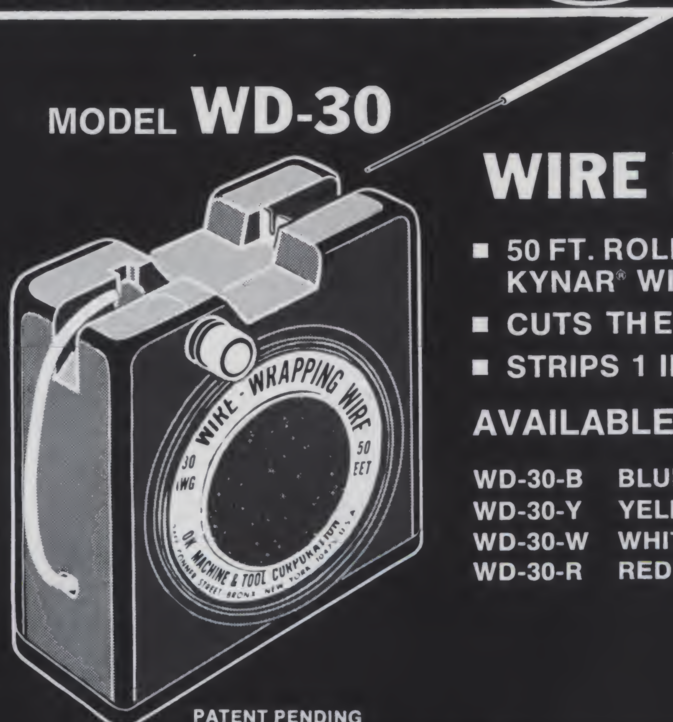

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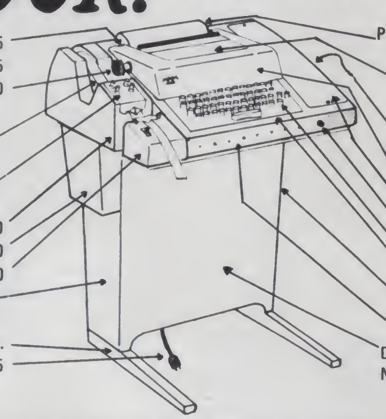

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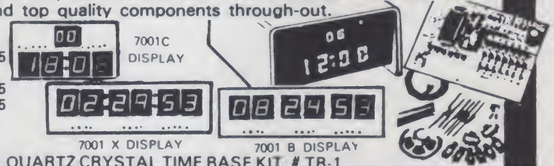

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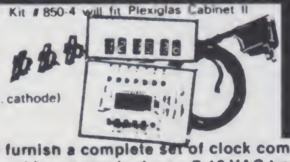

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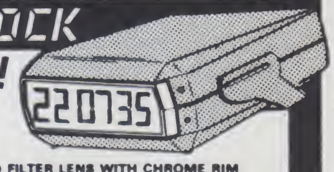

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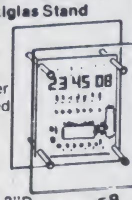

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$23.50 ea. 2/$45.

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC, 12/24 Hr. time, 50/60 HZ., Plug-Transformer, Line Cord, Switches, and all Parts. (Ideal Fit in Cabinet II) Kit # 5314-5

WITH PC Boards $19.95 2/$38.

JUMBO DIGIT CONVERSION KIT — $ 9.95 ea.

Convert small digit LED clock to large .5" displays. Kit includes 6 - LED's, Multiplex PC Board & easy hook-up info.
Kit # JD-1CC For common Cathode
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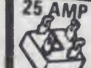
TELEPHONE FORMAT KEYBOARD

BY Chomerics
EF-21360
2-1/4"x3"

5/32" thick

$4.95
6/$28.

25 AMP BRIDGE



$1.95 ea.
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NEW LSI TECHNOLOGY FREQUENCY COUNTER KIT

8 LARGE .4" RED LED DIGITS

Kit #FC-50 • 8 IC's • XTAL TIME BASE

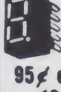
A truly "State of the Art" counter using quality components throughout.

KIT INCLUDES: DETAILED INSTRUCTIONS, XTAL, TOP QUALITY FIBERGLASS DOUBLE SIDED PC BOARD, IC'S WITH SOCKETS AND ALL PARTS LESS POWER SUPPLY AND CABINET.

50 MHZ COUNTER KIT	#FC-50	$69.95
5 VOLT REGULATED 1 AMP POWER SUPPLY KIT	#PS-02	$9.95
350 MHZ PRESCALER KIT	#PSL-350	23.95
650 MHZ PRESCALER KIT	#PSL-650	$29.95
CABINET [& MTG HARDWARE]	#CAB III	$19.95

[CABINET WILL HOUSE #FC-50, #PS-02, AND A PRESCALER]

Fairchild Super Digit FND-359



.4" Char. Ht. 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70.

95¢ ea, 10/$8.50
100/$79.00

SET OF 6 FND-359 WITH MULTIPLEX PC BOARD $6.95

NYLON WIRE TIES

8" TIE-WRAP 100/$1.95
4" TIE-WRAP 100/$1.75

PLUG TRANSFORMERS

12 VAC at 150 MA	$ 2.50
12 VAC at 500 MA	3.50
7VAC at 1.75 VA	$3.50

SCHOTTKY TTL

74S00	$ .35
74S01	40
74S04	.55
74S05	.60
74S09	.55
74S10	.40
74S20	.50
74S22	45
74S40	45
74S50	45
74S51	55
74S60	85
74S64	55
74S74	85
74S75	1.75
74S78	1.50
74S86	.95
74S107	.95
74S112	95
74S113	1.40
74S114	.95
74S133	75
74S134	.75
74S138	1.75
74S139	1.50
74S151	1.95
74S153	1.95
74S155	1.95
74S156	1.95
74S157	1.80
74S158	2.50
74S174	2.50
74S175	2.50
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MM 5312	$ 4.95
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7447	$ 95
7448	95
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VOLTAGE REGULATORS

LM 309 H	TO-5	$ 95
LM 309 K	TO-3	1.25
7805	TAB	.95
7812	TAB	1.25
7812	TO-3	1.50
7815	TO-3	1.25
7815	TAB	1.25
78L 15	TO-5	.75
7824	TO-3	1.25
723	DIP	.75
723	TO-5	.75

PROM

1702 E Prom	$8.95
5203 E Prom	$8.95

SPECIAL IC'S

7207A	INTERSIL	[illegible]
7208	INTERSIL	[illegible]
MC14553	MOT	$ 9.95
MC14410	MOT	$12.50
2513	SIG	$ 9.95

IC SOCKETS

PINS	1-24	25	100
8	$ 25	$ 22	$ 20
14	25	22	.20
16	28	25	23
18	.31	.28	26
24	50	.45	40
28	60	55	.50
40	.75	.70	65

XTAL

5.242880 MHZ. $4.95
3.579545 MHZ. $1.95

MOLEX PINS

$9.95 Reel of 1000
100 for $1.25

TRANSISTORS

2N2222 A	TO-18	3/$1.00
2N2712	TO-98	5/$1.00
2N3415	TO-9	5/$1.00
2N3704	TO 92	5/$1.00
2N4400	TO 92	5/$1.00
2N4125	TO 92	5/$1.00
2N4249	TO 92	5/$1.00
2N4437	TO 92	5/$1.00
2N6027	PUT	2/$1.00
2N5457	N J Fet	2/$1.00

DIODES

IN 4002	1A, 100 PIV	12/$1.00
IN 4005	1A, 600 PIV	11/$1.00
IN 4007	1A, 1000 PIV	10/$1.00
RECTIFIER	2.5A, 1000 PIV	4/$1.00
IN 914	SIL. SIGNAL	20/$1.00
IN 4148	SIL. SIGNAL	20/$1.00
DYAC	28V	4/$1.00

LINEAR

555 TIMER	2/$1.00
556 DUAL TIMER	.95
565 PLL	95
566 FUNCTION GEN.	1.75
567 TONE DECODER	1.75

TRANSISTOR SOCKET TO-5/18 GOLD PINS

5/$1.00

7-SEG LED

COMMON CATHODE

	COLOR	HT	DEC PT	PR EA
FND 359	RED	4"	RHDP	$ 95
FND 503	RED	5"	RHDP	$1 35
DL 750	RED	6"	LHDP	$2 95
XAN 654	GREEN	6"	NDP	$1 95
XAN 664	RED	6"	NDP	$1 95

COMMON ANODE

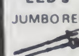
DL 747	RED	6"	LHDP	$1 95
XAN-72	RED	3"	LHDP	$1 25
MAN 72	RED	3"	LHDP	$1 25
XAN 81	YELLOW	3"	RHDP	$1 75
XAN-351	GREEN	3"	RHDP	$1 50
XAN 362	ORANGE	3"	LHDP	$1 50
XAN 662	RED	6"	NDP	$1 95
XAN-692	RED	6"	NDP	$1.95

OP AMPS

	3/$1.00
301	TO-5
709	DIP
709	TO 5
741	DIP
741	M-DIP
741	TO-5
747	TO 5

DISCRETE LED's

JUMBO RED



10 FOR $1.00
100 FOR $9.50

PC TRIM POTS

25K 6/$1.00
4.7K 6/$1.00

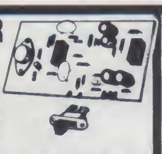
SPECTROL 10K 10 TURN 95c 4/$3.00

CMOS

	ea.
4001	$ .20
4002	.20
4010	.40
4011	.20
4013	.40
4015	.95
4016	.40
4023	.20
4025	.20
4027	.40
4028	.85
4030	.35
4042	.75
4044	.60
4046	1.75
4049	.40
4050	.40

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND KEYLESS ALARM HAS PROVISION FOR POS & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD UNIT MOUNTS UNDER DASH - REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED



KIT #ALR-1 $9.95
#ALR-1WT WIRED & TESTED $19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 $8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. $3.50

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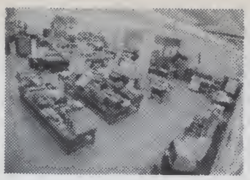


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IMM ROM CONTROL KIT EXPANSION TO 1 MEG.
KIT.................$299
ASSEMBLED........... 399

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4K MEMORY KIT........139
PIC-8 PRIORITY INT...125
SERIAL I/O KIT.......125

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32K RAM BOARD....KIT $ 749
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ASSEMBLED 679

PROM 4-512 KIT........ 165
UCRI-1 KIT............ 59
CABLE A KIT........... 18

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SWTPC 6800.................$395

- 512 BYTES OF ROM
- RS232 OR 20 mA
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MPA.......145
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MPE.....14.95
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MPP..... 42.50
MPS..... 37.50
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MPD..... 35
MPF..... 30
MPMx.... 35
MPL..... 35
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4K MEMORY........... $100
CT 64 TERMINAL KIT.. 325

MPCb,MPSb,MPLb, EACH 9.50
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GT61................. 99
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CTS.................39.95
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-INTERFACE 2.00
PP40 PRINTER 250

SMOKE SIGNAL BROADCASTING 16K RAM............. $595

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FROM NATIONAL SEMICONDUCTOR $99
KEYBOARD KIT...$95

LEAR SIEGLER ADM-3A

WITH CURSOR CONTROL
- 12" CRT • RS232
- 24 LN x 80 CHAR
- 20 mA LOOP

KIT..... $875
+ $25 SHIPPING

★ BUILT UNITS

ICOM MICROFLOPPIES

PLUG COMPATIBLE FOR S100 BUS...FD2411.... $1095
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ICOM FLOPPIES:

FF36-1	FRUGAL	1195
FF36-2	DUAL FRUGAL	1895
360-58	BUILT; INTERFACE 8080	300
S171	POWER SUPPLY	250
FD360-2-5	DUAL SYSTEM	3000

KIM-1 6502........$245

KIM-2 4K............ 179
KIM-3 8K............ 289
MANUALS PACKAGE..... 15

TARBELL AUDIO CASSETTE KIT................. 120

INTERCEPT JR PDP8 ON A CHIP!

FROM INTERSIL, INC.
12K RAM............ 145
ROM/PROM BOARD......74.65
(YOU ADD MEMORY CHIPS)
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AUDIO VISUAL BOARD.. 125

USED PERIPHERALS FOR MICROSYSTEMS

90 DAY USED GEAR WARRANTEE

HAZELTINE 1000 $795

+ 35 lb SHIPPING

VIDEO DISPLAY TERMINAL. 12 LINES x 80 CHAR., 5 x 7 DOT MATRIX, 525 LINE RASTER. BUILT & TESTED; PLUG AND GO!

ALL an ASR33 is. . . and MORE!

OLIVETTI TE318 --BACK IN STOCK!-- RS232 INTERFACE, QUIET OPERATION, 10 CPS, PRINTER, BUILT-IN PAPER TAPE READER/PUNCH, ELECTRIC TYPEWRITER KEYBOARD WITH ADDITIONAL 10 KEY NUMERIC PAD, YOUR CHOICE OF FRICTION OR SPROCKET FEED, LIGHTED PLATEN AREA FOR EASY READING, STANDARD PAPER AND TAPE, SUPPORTED BY OLIVETTI.

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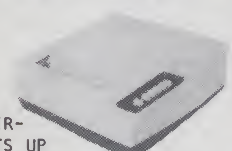


THERMAL PRINTER. PARALLEL PRINTER W/ ADDITIONAL CIRCUIT BOARDS TO PROVIDE SERIAL INTERFACE, PRINTS UP TO 30 CPS, 100Vac PS USES WIDELY AVAILABLE NCR PAPER, 96 CHAR ASCII 80 COL, CRT COMPATIBLE 5 x 7 DOT MATRIX, SOLID STATE WITH LESS THAN 25 MOVING PARTS.

IBM 731 ....$750

SELECTRIC I/O + $25 SHIPPING

$8\frac{1}{2}$" PLATEN, PINFEED, EBCDIC, U/L CASE, DUAL COLOR RIBBON, 115V

GREEN PHOSPHOR VIDEO MONITOR

$150 + $25 SHIPPING

STANDARD 1V P TO P COMPOSITE VIDEO INPUT, 16 MHz BANDWIDTH, RASTER SCAN 12x12x13" WITH POWER SUPPLY, VIDEO AMPLIFIER, DRIVING CIRCUITRY VENTILATION MUFFIN FANS, 7x9" HORIZONTAL VIEWING CAPABLE OF 24 LINES x 80 CHAR., ANTIGLARE $\frac{1}{4}$" ETCHED GRADIENT DENSITY FACE PLATE, 115Vac, 60 W.

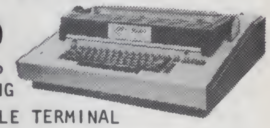
TECHTRAN 4100 $595

TAPE CASSETTE DRIVE + $25 SHIPPING

CAN RUN DIRECTLY FROM TERMINAL INDEPENDENT OF CPU. FULL EDIT CAPABILITY.

COPE 1030

$895 + 70 lb SHIPPING

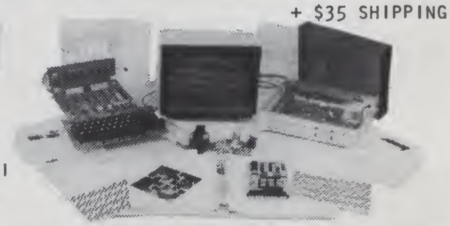


IBM 2741 COMPATIBLE TERMINAL

"SELECTRIC BASED" PORTABLE CONVERSATIONAL DATA TERMINAL, PRINTS UP TO 15 CPS.

U-BUILD-IT SYSTEM $649

+ $35 SHIPPING



SC/MP MICROCOMPUTER: 256 x 8 RAM, 512 x 8 ROM; GREEN PHOSPHOR VIDEO MONITOR: 12" RASTER SCAN; SWTPC CT-64: 64 CHAR X 16 LNS, ASCII KEYBOARD; SWTPC AC-30 AUDIO CASSETTE INTERFACE. *OTHER PACKAGE PLANS - SEND FOR OUR CATALOG.

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1N914	100v	10mA	.05
1N4004	400v	1A	.08
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.03
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.25
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.95

Molex pins .01 To-3 Sockets .25
2 Amp Bridge 100-prv 1.20
25 Amp Bridge 200-prv 1.95

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2N2222 NPN	.15
2N2907 PNP	.15
2N3740 PNP 1A 60v	.25
2N3906 PNP	.10
2N3054 NPN	.35
2N3055 NPN 15A 60v	.50
T1P125 PNP Darlington	.35
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D.L.747 7 seg 5/8" high com-anode	1.95
XAN72 7 seg com-anode	1.50
FND 359 Red 7 seg com-cathode	1.25
HP276 com-cathode	1.25

C MOS

4000	.15
4001	.20
4002	.20
4004	3.95
4006	1.20
4007	.35
4008	1.20
4009	.30
4010	.45
4011	.20
4012	.20
4013	.40
4014	1.10
4015	.95
4016	.35
4017	1.10
4018	1.10
4019	.70
4020	.85
4021	1.35
4022	.95
4023	.25
4024	.75
4025	.35
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.95
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	1.25
4044	.95
4046	1.50
4049	.80
4050	.60
4066	1.35
4069	.40
4071	.35
4082	.45

— T T L —

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.45
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.35
7438	.35
7440	.25
7441	1.15
7442	.55
7443	.85
7444	.45
7445	.80
7446	.95
7447	.95
7448	.95
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.45

7473	.25
7474	.35
7475	.35
7476	.30
7480	.55
7481	.75
7483	.95
7485	.95
7486	.30
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.40
7494	1.25
7495	.60
7496	.80
74100	1.85
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	1.00
74150	1.00
74151	.75
74153	.95
74154	.75
74156	1.15
74157	.65
74161	.85
74163	.95
74164	.60
74165	1.50
74166	1.35
74175	.80

74176	1.25
74180	.85
74181	2.75
74182	.95
74190	1.75
74191	.35
74192	1.65
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.25
74H01	.25
74H04	.25
74H05	.25
74H08	.35
74H10	.35
74H11	.25
74H15	.30
74H20	.30
74H21	.25
74H22	.40
74H30	.25
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.25

74H72	.55
74H101	.75
74H103	.75
74H106	.95
74L00	.35
74L02	.35
74L03	.30
74L04	.35
74L10	.35
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.55
74S00	.55
74S02	.55
74S03	.40
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.25
74S50	.25
74S51	.45
74S64	.25
74S74	.40
74S112	.90
74S114	1.30

74S133	.45
74S140	.75
74S151	.35
74S153	.35
74S157	.80
74S158	.35
74S194	1.05
74S257(8123)	.25
74LS00	.45
74LS01	.45
74LS02	.45
74LS04	.45
74LS05	.55
74LS08	.45
74LS09	.45
74LS10	.45
74LS11	.45
74LS20	.40
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.40
74LS40	.55
74LS42	1.75
74LS51	.65
74LS74	.75
74LS86	.75
74LS90	1.30
74LS93	1.00
74LS107	.95
74LS123	1.00
74LS151	.75
74LS153	1.20
74LS157	.85
74LS164	1.90
74LS367	.85
74LS368	.70

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9301	.85
9309	.35
9322	.85
95H03	.55
9601	.75
9602	.50

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1702A	7.95
MM5314	3.00
MM5316	3.50
2102-1	1.75
2102L-1	1.95
TMS6011NC	6.95
8080AD	15.00
8T13	1.50
8T23	1.50
8T24	2.00
2107B-4	4.95

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8836	.95
MCT2	.95
8038	3.95
LM201	.75
LM301	.25
LM308 (Mini)	.75
LM309H	.65
LM309K(340K-5)	.85
LM310	1.15
LM311D(Mini)	.75
LM318 (Mini)	.65

LM320K5	1.65
LM320K12	1.65
LM320T12	1.25
LM320T15	1.65
LM339	.95
7805 (340T-5)	.95
LM340T-12	1.00
LM340T-15	1.00
LM340T-18	1.00

LM340T-24	.95
LM340K-12	2.15
LM340K-15	1.25
LM340K-18	1.25
LM340K-24	.95
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LM380	.95
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LM711	.45

LM723	.45
LM725	1.75
LM739	1.50
LM741 8-14	.20
LM747	1.10
LM1307	1.25
LM1458	.95
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LM75451	.65
NE555	.50
NE556	.95
NE565	.95
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NE567	1.35
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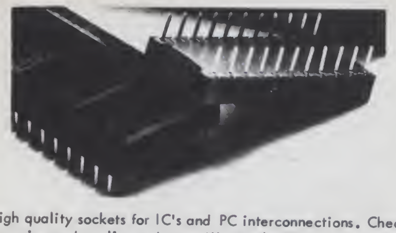

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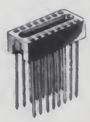
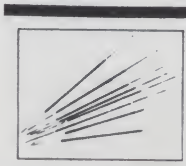
	1-9	10-24	25-100
SKT-0802 8 pin	.15	.15	.14
1402 14pin	.18	.17	.16
1602 16pin	.20	.19	.18
1802 18pin	.27	.26	.25
2002 20pin	.29	.28	.27
2202 22pin	.35	.34	.33
2402 24pin	.36	.35	.34
2802 28pin	.42	.41	.40
4002 40pin	.60	.57	.53



3 Level Wire Wrap Gold

	1-9	10-24	25-100
SKT-1400	.38	.37	.36
1600	.42	.41	.40
1800	.73	.65	.59
2400	1.00	.91	.83
4000	1.69	1.51	1.37



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Highest quality 30 ga. Kynar insulated silver plated wire for wrapping. Stripped 1" on both ends. Indicated lengths are lengths of insulated portion. Packed 100 per sturdy plastic vial or 1000 per poly bag. Compare our prices!!!. Available in Black, Red, Yellow and Green. State color desired.

Length	Price per tube of 100	Price per bag of 1000
1"	$1.48 (WW30VC-1)	$11.84 (#WW30BK-1)
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ROLLS OF WIRE SAME AS ABOVE (30 ga. KYNAR)
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D2135 400V, 25A.................................. $1.00
D2138 600V, 25A.................................. $1.55
D3289 200V, 100A................................. $5.85

Contract Cancellation Specials.....All Full Spec, NEW!!

SN7490.......39¢	2N3734.....38¢	2N3773 $1.75
LM320H-12...$1.29	2N5861.....75¢	2N4401..5/$1
1N5231A.... 25¢	1N3572.....90¢	2N4403..5/$1
1N5226B..... 35¢	G.E.D45C5 44¢	2N1557..$1.39
741(mini-dip..3/$1	50V, 3Amp Epoxy Bridge........ 79¢	

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NOW- at last, a high current adjustable regulator. Same simple circuitry as the popular 78GKC. Needs only two external resistors to program to any voltage between +5 and 30V @ 5A output.
78HGKC....................................$13.95
Spec...................................... .30

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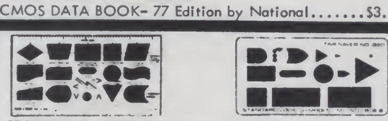
NEW 1977 VERSION OF NATIONAL'S CMOS
Greatly expanded now contains 530 pages of data on the 74C series as well as the popular 4000 series. Also has data and applications on the more complex CMOS products for which National has become famous.
CMOS DATA BOOK- 77 Edition by National.......$3.95



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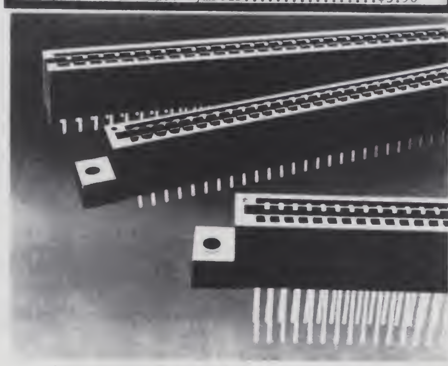
3/4 Size...................................$3.50
1/2 Size.....(Handy shirt pocket size)......$3.25
Computer Flow Chart Symbols................$3.50



100 PIN MINICOMPUTER PC CONNECTORS
2X50 with .125" spacing. Solder tail or wrap terminals. By TI.
PCC-100ST (solder)....$4.99 PCC-100WW....$4.99 4/$17.75

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N8885A...Quad 2-input NOR gate............8/$1.00
N8890A...Hex Inverter.....................6/$1.00
N8202A...10 bit "D" type register.......... $1.25

The following items are available in large quantities Dealer or manufacturer inquiry is invited.
2N3414.. NPN switch on reels...............10/$1
1N753A.. 6.2V, 5%, ½W Zener................ 5/$1
C106F2.. 50V, 4A SCR w/socket.............. 3/$1
1N967B.. 18V, 5%, ½W Zener................. 5/$1
42501-1 Quad Hi speed NPN transistor in 14 pin DIP package. Similar to Motorola MPQ3303....... 5/$1

MCM6571A is an 8192-Bit Horizontal-Scan (Row select) character generator with shifted characters. It contains 128 characters in a 7X9 matrix, and has the capability of shifting certain characters that normally extend below the baseline, such as j,y,g,p and q. A 7-bit address code is used to select one of the characters.
Features:
- .Static operation
- .TTL compatability
- .CMOS compatability (5V)
- .Shifted character compatability
- .Includes Greek alphabet
- .Maximum access time =500nS

(See article in March '77 issue of 73 Magazine for applications including TV-Computer interface)
MCM6571A.................................. $9.95
Specs..................................... $1.00

MM5320 TV SYNC GENERATOR I.C.
Generate all the sync pulses necessary for camera or video terminals. Use with MCM6571A in the TV-Computer interface. MM5320N..............................$18.80
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SC45E 500V, 10A Stud Triac.................. $1.59
Insulated Stud 400V, 10A TRIAC assembly with built-in diac. TRI-133.............................. $1.85

TIP-30 40V, 1 amp PNP Plastic................. 50¢
TIP-33 40V, 10Amp NPN Plastic............... $1.00

LM1815 ADAPTIVE SENSE AMP CHIP.
Used with motor control to adapt to variable input and noise levels. Applications include zero crossing switch, motor control, tachometers, motor testing.
LM1815N.....................................$5.72
Specs.. 30¢

1N5393 200V, 1.5A Diode. Sturdy replacement for 1N4003 at a good savings.....................15/$1

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MC14411 BIT RATE GENERATOR.
Single chip for generating selectable frequencies for equipment in data communications such as TTY, printers, CRT s or microprocessors. Generates 14 different standard bit rates which are multiplied under external control to 1X, 8X, 16X or 64X initial value. Operates from single +5 volt supply. MC14411........................ $11.98
4 pages of data..................................... .40
Crystal for the above.......................... $4.95

- Accuracy ±0.05% of Reading ±1 Count
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- Z_{in} > 1000 M ohm
- Auto-Polarity and Auto-Zero
- Single Positive Voltage Reference
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- Uses On-Chip System Clock, or External Clock
- Low Power Consumption: 8.0 mW typical @ ±5.0 V
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Single chip combines linear and CMOS digital to bring you the simplest yet DVM approoch. Requiring only 4 external passive parts, this subsystem gives you: Auto polarity, auto zero, single voltage reference, 8 mW operation, overrange, underrange signals, 25 conversions per second and .05% ± 1 count accuracy! 100 uV resolution. 24 Pin DIP.
MC14433P...........with specs................$19.55

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- UP TO 300 BPS

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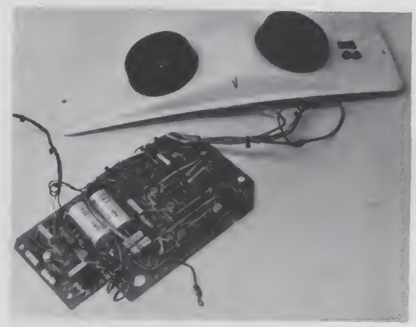

ACCOUSTICAL MODEMS – ORIGINATE ONLY
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Physically fit into Model 33 Teletype. Manufactured by **Paragon** partial documentation 2 for $25

CANNON 25 PIN CONNECTOR

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Male Connector *NEW* **$2.50** Each

Solder Type Cover **$1.00** Each

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Modems: $2.00 each; 2 for $4.00 UPS
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Items are either new (specified) or they are used (tested or untested) and no other warranty is made or implied.

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All Items NEW

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SIO	(DLVII)	$990	$875
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Ext. Arith.	(KEVII)	175	155
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(8KB)		625	550
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NEW

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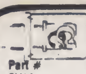

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
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CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

XR-2206KB Kit $29.95 Special XR-2206KA Kit $19.95

EXAR

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XR-205	$8.40
XR-2206CP	4.49
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XR-1310CP	$3.20
XR-1310EP	3.20
XR-1800P	3.20
XR-2567	2.99

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XR-4136	.99
XR-1468	3.85
XR-1488	5.80
XR-1489	4.80
XR-2208	5.20

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XR-320P	1.55
XR-556CP	1.85
XR-2556CP	3.20
XR-2240CP	3.25

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XR-210	5.20
XR-215	6.60
XR-567CP	1.95
XR-567CT	1.70

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PRINTED CIRCUIT EDGE-CARD

.156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
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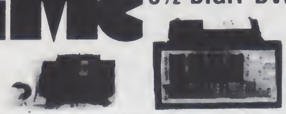
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINIATURE

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

iMC 3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95

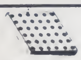
B. 5V Power Supply $14.95

Vector

Etching Kits		
32 X A-1	P.C. Etch Materials Kit enough for 5 circuit boards	$29.95 ea.
27 X A-1	Etched Circuit Kit Complete kit — only add water	$ 9.95 ea.
Plugboards		
3662	6.5 X 4.5 X 1/16 Epoxy glass P-Pattern-44 P.C. Tabs-spaced .156"	$ 6.95 ea.
8800V	Universal Microcomputer/Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5.313 X 10 X 1/16 copper clad	$19.95 ea.

1/16 VECTOR BOARD

	0.1" Hole Spacing Part No.	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12



HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

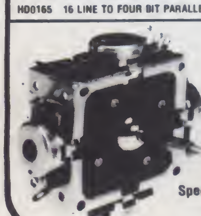
63 KEY KEYBOARD

This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four * potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

Special ***5K Pots $4.95**

***100K Pots $7.95**

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8080A	CPU	$19.95
8212	8 Bit Input/Output	4.95
8214	Priority Interrupt Control	15.95
8216	Bi-Directional Bus Driver	6.95
8224	Clock Generator/Driver	10.95
CDP1802 - with user manual		39.95
8228	System Controller - Bus Driver	$10.95
MC6800L	8 Bit MPU	35.00
MC6820L	Periph. Interface Adapter	15.00
MC6810AP1	128 x 8 Static RAM	6.00
MC6830L7	1024 x 8 Bit ROM	18.00
Z80	CPU	49.95

CPU'S

8080	Super 8008	24.95
8080A	Super 8008	19.95

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2524	512 Dynamic	2.49
2525	1024 Dynamic	6.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	Special 5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

ROM'S

2513(2140)	Char. Gen.-upper case	$ 9.95
2513(3021)	Char. Gen.-lower case	9.95
2516	Char. Gen.	10.95

RAM'S

1101	256 x 1	Static	$ 1.49
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00

PROMS

1702A	2048	Famos	$ 9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95
6331-1	256	Tri-State Bipolar	2.95

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AY-3-8500-1	$16.95					8T97	2.00
MC3061P	3.50	CD4508	6.75	82S115	25.00	3341	6.95
MC4016P (74416)	7.50	CD4515	6.50	5841	9.95	9368	3.95
MC14583	3.50	CD4520	2.70	MK50240	17.50	MC1408L7	9.95
MC14562	14.50	MCM6571	17.50	11C90	19.95	LD110/LD111	25.00/set
CD4059	9.95	MCM6574	17.50	DS0026CH	3.75	AY-5-9100	17.50 ea
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- See ones and zeros displayed on your CRT, octal or hexadecimal format
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  - — Troubleshooting microprocessor address, instruction, and data flow
  - — Examine contents of ROMS
  - — Tracing operation of control logic
  - — Checking counter and shift register operation
  - — Monitoring I/O sequences
  - — Verifying proper system operations during testing

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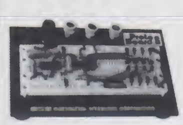

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PB100 - 4.5" x 6"	$ 19.95
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PB102 - 7" x 4.5"	39.95
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PB104 - 9.5" x 8"	79.95
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Logic Monitor $84.95
for DTL, HTL, TTL or CMOS Devices

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
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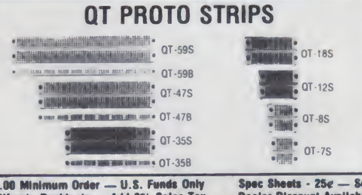
DM1 - Circuit Designer	54.95
DM2 - Function Generator	69.95
DM3 - RC Bridge	59.95

QT PROTO STRIPS



QT type	#holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

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DIGITAL AUTO INSTRUMENT

SEVEN DIFFERENT INSTRUMENTS!

MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS.

Please specify which one of the seven models you want when ordering - these do not all come in one unit. Each model must be bought separately

1 TACHOMETER 0-9900 RPM 4, 6 or 8 Cylinders
2 WATER TEMP. 100-250° F
3 FUEL LEVEL Percentage Low Fuel Indicator
4 SPEEDOMETER* 0-99 MPH
5 OIL PRESSURE 0-80 PSI
6 OIL TEMP 200-350° F
7 BATTERY MONITOR ±1 Volts From 11-15 VDC

BRIGHT YELLOW ORANGE .3" LED DISPLAY!

Kit includes case, bracket and all components — complete. Nothing else to buy! 12 Volt NEG GRD.

DIMENSIONS 4½ x 4 x 2 **KIT: $49.95**

* Add $10.00 for required speed transducer **ASSEMBLED: $59.95**

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

ELECTRONIC 'PENDULUM' CLOCK

- Swing Pendulum
- .7" Hours and Minutes Display
- 12 or 24 Hour Mode
- Time Set Push Buttons
- Alarm Feature

Kit-unfinished (case unassembled) **$59.95**

Assembled-stained (case assembled) **$69.95**

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control

Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip. Large .4" LED's Accuracy better than ± min. per mo. internal battery backup. 12 volt non-polar operation.

DIMENSIONS 4½" x 4" x 2"
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) **$6.50**

JE700 CLOCK

12 or 24 Hour

115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip

$17.95

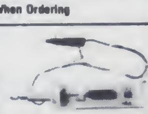
DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95 **4 DIGIT ASSEMBLED $59.95**
6 DIGIT KIT $69.95 **6 DIGIT ASSEMBLED $79.95**

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

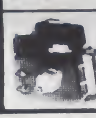
JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (H) 1 (LOW) - 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result

$9.95 Per Kit
printed circuit board

T²L 5V 1A Supply



This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

MICROCOMPUTER

PROM'S

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1702A	256 x 8 Bit 1 us TS Erasable	5.00
1702AL	256 x 8 Bit 1 us TS Eras Lo Pwr	7.00
2704	512 x 8 Bit 450 ns TS Erasable	30.00
2708	1024 x 8 Bit 450 ns TS Erasable	35.00
5203AQ	256 x 8 Bit 1 us TS Erasable	9.00
5204AQ	512 x 8 Bit 1 us TS Erasable	12.00
HM7611 5	256 x 4 Bit 60 ns TS	3.25
74S287	256 x 4 Bit 65 ns TS	9.00
74S387	256 x 4 Bit 65 ns OC	9.00
82S23B	32 x 8 Bit 50 ns OC	4.00
82S129B	256 x 4 Bit 50 ns TS	4.25
8223B	32 x 8 Bit 50 ns OC	4.50

WAVEFORM GENERATOR

8038	VCO	4.50
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MC6571	7x9 7 line	12.00
2431-1	CM3421 (Signetics)	5.00

SHIFT REGISTERS

DYNAMIC

1404AN	1024 x 1 Bit 2.5 MHz	3.00
2505K	512 x 1 Bit 2.5 MHz	3.00

STATIC

MM506	100 x 2 Bit	.89
2509K	50 x 2 Bit 1.5 MHz	1.00
2518B	32 x 6 Bit 2.0 MHz	3.95
2533V	1024 x 1 Bit 1.5 MHz	2.00
TMS3002	50 x 2 Bit 1.0 MHz	1.00
TMS3112	32 x 6 Bit 2.0 MHz	3.95
MM5058	1024 x b Bit 1.5 MHz (8 pin)	2.00

MISC OTHER COMPONENTS

NH0025CN	Dual Low Cost MOS Clock Driver	1.75
NH0026CN	5 MHz Dual MOS Clock Driver	3.00
N8T20	Bi Directional One Shot	4.00
N8T26	Quad Bus Driver/Receiver	3.25
N8T97	Tri State Hex Buffer	1.15
DM8098	Tri State Hex Inverter	1.00
1488	RS232 Quad Line Driver	1.95
1489	RS232 Quad Line Receiver	1.95
D 3207A	Quad NAND to MOS Driver	2.50
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MM-5369	Oscillator Pre Scaler	2.00
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U A R T S

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8008-1	8 Bit CPU	18.75
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8228	System Controller & Bus Driver	9.25
8251	Programmable Communication Int	12.00
8255	Programmable Peripheral Interface	12.00
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1103	1024 x 1 Bit 300 ns	1.50
2107A	4096 x 1 Bit 300 ns	6.00
2107B	4096 x 1 Bit 200 ns	6.50
2107B 4	4096 x 1 Bit 270 ns	5.00
2107B 6	4096 x 1 Bit 350 ns	4.50
4008P 6	1024 x 1 Bit 500 ns	2.75
4050NL	4096 x 1 Bit 300 ns	4.00
MM5261	1024 x 1 Bit 400 ns	3.00
MM5262	2048 x 1 Bit 365 ns	3.00
MM5270	4096 x 1 Bit 200 ns (18 pin)	4.00
MM5280	4096 x 1 Bit 200 ns (22 pin)	6.00

STATIC RAMS

21102 1	1024 x 1 Bit 500 ns TS	2.00
31101	16 x 1 Bit 110 ns OC	2.00
1101A	256 x 1 Bit 1 us TS	1.00
2101	256 x 4 Bit 1 ns TS	3.00
2102	1024 x 1 Bit 1 us TS	1.50
2102 1	1024 x 1 Bit 500 ns TS	1.75
2111A 4	256 x 1 Bit 450 ns TS (18 pin)	4.15
2112A 4	256 x 4 Bit 450 ns TS (16 pin)	2.15
2501B	256 x 1 Bit 1 us	1.45
3107	256 x 1 Bit 80 ns OC	2.95
7489	16 x 4 Bit 280 ns TS	3.00
74S201	256 x 1 Bit 50 ns TS	4.75
91102A	1024 x 1 Bit 500 ns TS	2.00
7489	16 x 4 Bit 60 ns OC	2.25
8225	16 x 1 Bit 50 ns OC	1.50
8599	16 x 1 Bit 50 ns TS	1.50

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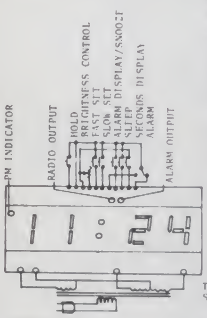
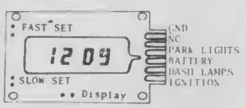


FEATURES
*4 digit 0.5 display
*Complete, needs only transformer & switches
*Clock Radio Alarm
*12 hr & 60Hz
*Power Failure Indicator
*Direct Drive No RFI

APPLICATIONS
*Clock radio timers
*Desk Clocks
*Instrument panel clocks

MA 1002 A
$10.95

TRANSFORMER, 14 VCT AC SCHEMATIC TO POWER MA 1002A $1.75

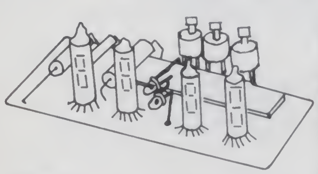


FEATURES
* Operates on 9 12 V DC
* 0.3" green display
* Internal time base
* Display color filterable to blue, green & yellow
* Lock out of time set when display is "OFF"

APPLICATIONS
* In dash autoclocks
* Recreation vehicles
* Aircraft/Marine clocks
* Portable battery operated instruments

MA 1003
$24.95

NIXIE DISPLAY KIT



FEATURES
* MM5316 Clock Chip
*Needs only case & 12 V AC @ 200 ma
*Blanking control
*AM PM Option
*24 hr Capability
*59 minute timer
*Power Failure indicator
*24 hr clock radio

NIXIE CLOCK KIT
$12.95
Transformer 110 14V AC 200ma $1.50

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MM 5369	17 Stage Osc/Divider	2.00

CLOCK CHIPS

MM5312N	4 Digit w/BCD 7 Seg 12/24 hr 50/60 Hz	4.50
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MM5375NAC	4/6 digit, date counter, 50Hz	2.00
7001	6 digit calender, alarm, 12/24 hr	5.95

74LS00

Low Power Schottky

74LS00	.40
74LS02	.40
74LS03	.40
74LS04	.40
74LS05	.40
74LS08	.40
74LS10	.40
74LS11	.40
74LS12	.50
74LS20	.40
74LS21	.40
74LS30	.40
74LS32	.40
74LS37	.50
74LS42	.90
74LS51	.40
74LS73	.60
74LS74	.65
74LS76	.60
74LS78	.80
74LS85	2.00
74LS86	.55
74LS95	2.00
74LS107	.55
74LS109	.60
74LS112	.60
74LS113	.60
74LS122	.60
74LS139	1.30
74LS151	1.50
74LS153	1.60
74LS155	1.60
74LS157	1.30
74LS161	1.50
74LS169	2.00
74LS174	1.25
74LS175	1.30
74LS191	2.45
74LS192	1.95
74LS193	2.45
74LS196	2.60
74LS248	1.35
74LS251	2.00
74LS266	.75
74LS363	.70
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74LS368	1.00
74LS386	.75

CMOS

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4000	Dual 3-Input NOR Gate/Inver	.25
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4020	14 Bit Binary Counter	1.25
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4029	4 Bit BIN/BCD UP/DN CTR	1.90
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4049	Hex Inverter/Buffer	.75
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4051	8 Channel Analog Multiplexer	1.10
4052	Dual 4 Channel Analog Mx.	1.10
4053	Triple 2 Channel Mltplx	1.10
4060	14 Stage Binary Ctr/Osc	3.25
4061	256 x 1 Static RAM	7.00
4063	4-Bit Magnitude Comparator	2.50
4066	Quad Bilateral Sw.	.85
4068	8-Input NAND Gate	.38
4069	Hex Inverter	.40
4070	Quad Excl OR Gate	.38
4071	Quad 2 Input OR Gate	.38
4072	Dual 4 Input OR Gate	.38
4073	Triple 3 Input AND Gate	.38
4075	Triple 3 Input OR Gate	.38
4076	Quad D Type Register	1.85
4078	8-Input NOR Gate	.38
4081	Quad 2 Input AND Gate	.38
4082	Dual 4-Input AND Gate	.38
4093	Quad 2-1 NAND Schmitt Trigger	.75
4098	Dual Retrig/Reset M S Multi	2.50
4160	Decade Counter	1.75
4161	Binary Counter	1.75
4162	Decade Counter	1.75
4163	Binary Counter	1.75
4174	Hex D Flip-Flop	1.75
4175	Quad D Flip-Flop	1.60
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4510	BCD Up/Down Counter	1.75
4511	BCD to 7 Seg Latch/Decdr/Dr	2.00
4512	8 Channel data selector	1.50
4514	4/16 line decoder (hi)	4.75
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4520	Dual 4-Bit Binary Counter	1.65
4521	24 State Frequency Divider	3.25
4522	BCD Divide by N-Counter	1.75
4527	BCD Rate Multiplier	3.00
4528	Dual Monostable Mltvbr	1.75

CONNECTORS

EDGE CONNECTORS

10	Dual .156 W W Gold	.50
15	Dual .156 W W Gold	.75
22	Dual .156 Solder Gold	2.25
50	Dual .125 Solder Gold	5.00
50	Dual .125 Solder Gold (No Bolt Down Ears)	3.50
10	Molex type w/edge clip female & male (solder)	10/1.25

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25	Solder type (25 S) (Female)	3.90
25	Solder type (25 P) (Male)	3.50
	Male & female (25 P & 25 S)	6.50
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I C SOCKETS

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10	Transistor IC-10) Gold	.25
14	Lo Pro Tin	.25
14	Wire Wrap Gold	.30
16	Lo Pro Tin	.25
16	Standard P C Tin	.30
16	Wire Wrap Tin	.30
18	Lo Pro Tin	.25
22	Lo Pro Open Frame Tin	.50
22	Wire Wrap Tin	.95
24	Standard P C Tin	.50
24	Wire Wrap Tin	.85
28	Lo Pro (Open Frame) Tin	.40
28	Standard P C Tin	.60
28	Wire Wrap Tin	.95
40	Lo Pro (Open Frame) Tin	.50
40	Wire Wrap Tin	1.45

Bearcat® 210 $289.

The **Bearcat® 210** is a sophisticated scanning instrument with the ease of operation and frequency versatility you've dreamed of. Imagine, selecting from any of the public service bands and from all local frequencies by simply pushing a few buttons. No longer are you limited by crystals to a given band and set of frequencies. It's all made possible by *Bearcat* spaceage solid state circuitry. You can forget crystals forever.

Pick the 10 frequencies you want to scan and punch them in on the keyboard. It's incredibly easy. The large decimal display reads out each frequency you've selected. When you want to change frequencies, just enter the new ones.

Automatic search lets you scan any given range of frequencies of your choice within a band. Push-button lockout permits you to selectively skip frequencies not of current interest. The decimal display with its exclusive "rolling zeros" tells you which channels you're monitoring. When the *Bearcat* 210 locks in on an active frequency the decimal display shows the channel and frequency being monitored.

With the patented track-tuning system, the Bearcat 210 automatically aligns itself so that circuits are always "peaked" for any broadcast. Most competitive models peak only at the center of each band, missing the frequencies at the extreme ends of the band.

The Bearcat 210's electronically switched antenna eliminates the need for the long low band antenna. And a quartz crystal filter rejects adjacent stations as well as noise interference.

Call toll-free 800-521-4414 now to place a BankAmericard or Mastercharge order. This is our 24 hour phone to our order department and only orders may be processed on this line. To order in Michigan or outside of the U.S. dial 313-994-4441.

Add $5.00 for U.S. shipping or $9.00 for air UPS to west coast. Charge cards or money orders only please. International orders invited. Michigan residents add tax. Please write for quantity pricing.

Bearcat® 210 Features

- **Crystal-less**—Without ever buying a crystal you can select from all local frequencies by simply pushing a few buttons.
- **Decimal Display**—See frequency and channel number—no guessing who's on the air
- **5-Band Coverage**—Includes Low, High, UHF and UHF "T" public service bands, the 2-meter amateur (Ham) band, plus other UHF frequencies
- **Deluxe Keyboard**—Makes frequency selection as easy as using a push-button phone Lets you enter and change frequencies easily try everything there is to hear.
- **Patented Track Tuning**—Receive frequencies across the full band without adjustment Circuitry is automatically aligned to each frequency monitored.
- **Automatic Search**—Seek and find new, exciting frequencies.
- **Selective Scan Delay**—Adds a two second delay to prevent missing transmissions when "calls" and "answers" are on the same frequency
- **Automatic Lock-Out**—Locks out channels and "skips" frequencies not of current interest
- **Simple Programming**—Simply punch in on the keyboard the frequency you wish to monitor.
- **Space Age Circuitry**—Custom integrated circuits a *Bearcat* tradition.
- **UL Listed/FCC Certified**—Assures quality design and manufacture.
- **Rolling Zeros**—This *Bearcat* exclusive tells you which channels your scanner is monitoring.
- **Tone By-Pass**—Scanning is not interrupted by mobile telephone tone signal.
- **Manual Scan Control**—Scan all 10 channels at your own pace.
- **3-Inch Speaker**—Front mounted speaker for more sound with less distortion.
- **Squelch**—Allows user to effectively block out unwanted noise.
- **AC/DC**—Operates at home or in the car.

Bearcat® 210 Specifications

Frequency Reception Range

Low Band	32—50 MHz
"Ham" Band	146—148 MHz
High Band	148—174 MHz
UHF Band	450—470 MHz
"T" Band	470—512 MHz

*Also receives UHF from 416—450 MHz

Size
10⅝" W x 3" H x 7⅝" D

Weight
4 lbs. 8 oz.

Power Requirements
117V ac, 11W; 13.8 Vdc, 6W

Audio Output
2W rms

Antenna
Telescoping (supplied)

Sensitivity
0.6μv for 12 dB SINAD on L & H bands
U bands slightly less

Selectivity
Better than −60 dB @ ± 25 KHz

Scan Rate
20 channels per second

Connectors
External antenna and speaker; AC & DC power

Accessories
Mounting bracket and hardware
DC cord

TM
COMMUNICATIONS
ELECTRONICS

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Ann Arbor, Michigan 48106 USA

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BANKAMERICARD
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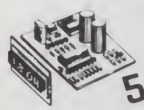
S. D. SALES CO.

P.O. BOX 28810 - K
DALLAS, TEXAS 75228

JUMBO LED CAR CLOCK

$16.95 KIT



50,000 Satisfied Clock Kit Customers Can't Be Wrong!

ALARM OPTION – $1.50
AC XFMR – $1.50

The Hottest Selling Kit We Ever Produced!

You requested it! Our first D.C. operated clock kit. Professionally engineered from scratch. Not a makeshift kluge as sold by others.
Features:
A. Bowmar Jumbo .5 inch LED array.
B. MOSTEK – 50250 – Super Clock Chip
C. On board precision crystal time base.
D. 12 or 24 hour Real Time Format.
E. Perfect for cars, boats, vans, etc.
F. P.C. Board and all parts (less case) included.

Specials!

3.579545 MHZ Time Base Crystal $1.25

39 MFD 16V Mallory Electrolytic 15 for $1.

28 PIN IC Sockets 3/$1.00

11,000 MFD 50WVDC Computer Grade Cap - $3.

1702A 2K EPROM

We tell it like it is! We could have said these were factory new, but here is the straight scoop. We bought a load of new computer gear that contained a quantity of 1701 A's in sockets. We carefully removed the parts, verified their quality, and are offering them on one heck of a deal. First come, first served. Satisfaction Guaranteed! U. V. Eraseable. (2.3 US access time.) NEW PRICE!

$2.95 each

UP YOUR COMPUTER!

21L02-1 1K LOW POWER 500 NS STATIC RAM
Time is of the essence!
And so is power. Not only are our RAM's faster than a speeding bullet but they are now very low power. We are pleased to offer prime new 21L02-1 low power and super fast RAM's. Allows you to STRETCH your power supply farther and at the same time keep the wait light off!

8 for $12.95

60HZ Crystal Time Base

$5.95 2/$10.

FEATURES:
A. 60HZ output with accuracy comparable to a digital watch.
B. Directly interfaces with all MOS clock chips.
C. Super low power consumption (1.5MA typ.)
D. Uses latest MOS 17 stage divider IC.
E. Elimiates forever the problem of AC line glitches.
F. Perfect for cars, boats, campers, or even for portable clocks at ham field days.
G. Small size; can be used in existing enclosures.
Kit includes Crystal, Driver IC, PC board, plus all necessary parts and specs. At last count – over 20,000 sold!

S.D. Sales Exclusive!

$12.95 *S. D. Sales Exclusive!* $12.95

MOS 6 DIGIT UP–DOWN COUNTER
40 PIN DIP. Everything you ever wanted in a counter chip. Features: Direct LED segment drive, single power supply (12 VDC TYPE), six decades up/down, pre-loadable counter, separate pre-loadable compare register with compare output, BCD and seven segment outputs, internal scan oscillator, CMOS compatible, leading zero blanking, 1MHZ. count input frequency. Very limited quantity!

IC's from XEROX

7400 – 9c	7430 – 9c	7493 – 26c	1402A–Shift Regulator–50c
7402 – 9c	7440 – 9c	74121 – 22c	MH0025CN – 55c
7404 – 9c	7437 – 10c	74123 – 32c	
7406 – 11c	7438 – 10c	74151 – 22c	
7407 – 11c	7451 – 9c	74155 – 22c	
7410 – 9c	7474 – 16c	74193 – 35c	
7416 – 13c	7475 – 24c	8233 – 35c	
7420 – 9c	7486 – 16c	Intel – 1302 – 45c	

IC'S REMOVED FROM PC BOARDS ALL TESTED: FULL SPEC.

1000 MFD
Filter Caps
Rated 35 WVDC Upright style with PC leads. Most popular value for hobbyists. Compare at up to $1.19 ea. from franchise type electronic parts stores.
4/$1.00

SLIDE SWITCH Assortment
Our best seller. Includes miniature and standard sizes; single and multi-position units. All new, first name brand. Try one package and you'll reorder more! Special!
12/$1.00

POWER RESISTOR 15 OHM 25W BY CLAROSTAT
75¢ ea.

RESISTOR ASSORTMENT
¼W 5% & 10%. PC leads. A good mix of values.

200/$2.

P.C. LEAD DIODES
1N4148/1N914 100/$2.00
1N4002 - 1A 100 PIV
40/$1.

Transistor Grab Bag no. 1
Just received a good, mixed lot of National TO92 plastic transistors. PNP & NPN, even a few FET's. 40 to 50% Yield. Untested. Asst.
500/$3.

DISC CAP ASSORTMENT
PC leads. At least 10 different values. Includes: .001, .01, .05 plus other standard values.

60/$1.00

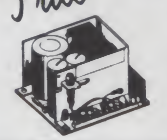
SIX DIGIT ALARM CLOCK KIT

$9.95 KIT
P.C. Board – $3.00
AC XFMR – $1.50
Do not confuse with Non-Alarm kits sold by our competition! Eliminate the hassle – avoid the 5314!

WE MADE A FANTASTIC KIT EVEN BETTER. REDESIGNED TO TAKE ADVANTAGE OF THE LATEST ADVANCES IN I.C. CLOCK TECHNOLOGY. FEATURES: LITRONIX DUAL ½" DISPLAYS, MOSTEK 50250 SUPER CLOCK CHIP, SINGLE I.C. SEGMENT DRIVER, SCR DIGIT DRIVERS. GREATLY SIMPLIFIED CONSTRUCTION. MORE RELIABLE AND EASIER TO BUILD. KIT INCLUDES ALL NECESSARY PARTS (except case). P.C.B. OR XFMR OPTIONAL.
NEW! WITH JUMBO LED READOUTS!

MOTOROLA SCR
2N4443. 8 AMP 400 PIV.
P.C. Leads. $3/$1.00
FAIRCHILD - TBA 641
4W. Audio power Amp. Just out! In special heat sink DIP. One super audio IC.
$1.50 with data
AC LINE FILTER
Rated 3 AMPS - 115/230V 50 to 400 HZ.
Noise Proof Your Computer
$3.00 each
GRAB BAG NUMBER 2
Mixed Motorola TO-18 case metal transistors. About 60% yield. PNP & NPN. Untested. A good assortment! 100 for $3.00
PRICES SHOWN SUBJECT TO CHANGE WITHOUT NOTICE.

Price Cut! ~~$15.95~~ **$12.**



COMPUTER POWER SUPPLY

A very fortunate purchase. One of the best industrial quality REGULATED supplies we have seen. High performance, small size. Input is 120VAC 60HZ. Has the following regulated outputs: –5VDC@800MA; –15VDC@1.25AMP; –25VDC@180MA. Sold at a fraction of original cost. Do yourself a favor and order NOW.

AMD – 1702A
Factory Prime Units – Brand New – 1.5 Micro-seconds Access Time. – $4.95 each
10 FOR $40. HUGE FACTORY DIRECT PURCHASE!

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CHEAP DC SUPPLY
Actually an AC adapter for calculators. 9VDC-no load. 6VDC@200MA. 4VDC@375MA
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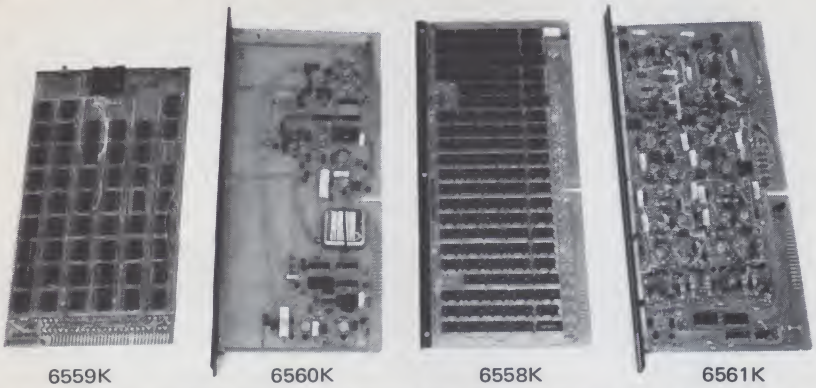
prototype boards   op-amp boards   crystal timer boards



6559K   6560K   6558K   6561K

We have assembled a fantastic lot of boards that have tremendous appeal for computer buffs, and any builder of electronic equipment. These boards are all out of an operating computer system that has been upgraded.

Board 6558K is a prototype board, that has from 75 to 100 wire wrap IC sockets, both 14 pin and 16 pin. 40 of the 14 pin sockets are in 16 pin holes, so that they may be replaced with 16 pin sockets if you need them. The sockets are at present wire wrapped, so you must remove the wiring by unwrapping it, but when you do you have a board worth over $175.00. Board is 13½"x6", has ground plane on one side, and Vcc plane on other. Ther are 128 gold plated edge contacts.

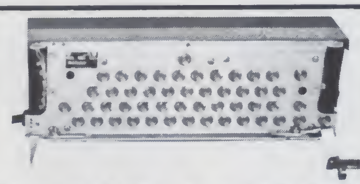
6559K is another wire wrap proto type board. It has a minimum of 50 sockets, 8 of which are 16 pin, the rest 14 pin. If more 16 pin are needed, the board is drilled for 16 pin sockets, so that the 14 pin sockets may be removed and replaced with 16 pin DIP sockets. The board is unique in that the wire wrap terminals are brought out to the top of the board, rather than the reverse side as the 6558M above. This board also is wire wrapped, and the preveious wiring must be unwound. The board contains a 6 position thumb wheel switch, and a SPST slide switch. There are 70 gold plated edge contacts, and board has a ground plane and a Vcc plane. 11½"x6"

7560K is a clock timing board. It contains a VECTRON CO-231T crystal oscillator including tuning option for an accuracy of .0001% Crystal frequency is 4.9152 which divides conveniently to 60 Hz with 3 SN7493, a SN7490, and a SN7470. it divides to 50 Hz. with 3 SN7493, 1 SN7492, and a SN7470. It goes to 1 Hz. with 3 SN7493, 1 SN7492 and 2 SN7490. This is a very flexible oscillator which can be used for any digital clock including clocks for automobiles, computer clocks etc. The crystal oscillator Is plugged into a board that was used for timing,,and contains many op-amps, transistors, SN7400 series ICs, dipped tantalum capacitors,plus many other components, more than enough to make your own timing board.

The latest catalog we have from VECTRON is dated 1972, and shows this oscillator at $75.00, plus $10.00 for the tuning option.

6561K is a parts board which contains 31 LM741 OP-AMPS., 32 transistors, over 75 1% precision resistors, a dozen or more dipped tantalum capacitors of various values, plus resistors, capcitors and diodes.

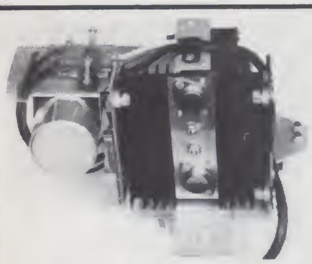
STOCK NO.6558K	75 to 100 socket proto type board	18.75	2/35.00
STOCK NO.6559K	50 Socket proto type board	11.75	2/22.00
STOCK NO.6560K	Crystal Oscillator board	16.95	2/32.00
STOCK NO.6561	Op—Amp Board	10.95	2/20.00



viatron typewriter robot

We have acquired a limited number of VIATRON System 21 Typewriter Robots. This robot converts your IBM (or other) typwriter to a printer for your computer. We have been using one here at DELTA, and after initial adjustments, it now prints all our labels for catalogs and orders. It was designed to be used in the VIATRON 21 system, but can be converted for use with any computer. We supply the Robot, a copy of the wiring of the logic card and drive card, as used with our VIATRON.

STOCK NO.5513K   VIATRON TYPEWRITER ROBOT $139.00   2/275.00



5 volt 8 amp. highly regulated supply

This heavy duty supply is rated at5 volts @ 8 Amps with .006% regulation. Ideal for any TTL device. It was originaly designed to operate at 48 Volts AC input, so we supply a transformer to get 48 volts to run this supply. Made by ACME for UNIVAC. Wt. with transformer is 15 lbs. Circuit diagram supplied.

STOCK NO.5514K Power Supply $23.50 ea.   2/45.00

videocube tv interface

The VIDEOCUBE is a fully self contained RF Oscillator, modulator and selector switch which allows easy interface with any video device to the RF input of a standard TV receiver. Drive to the VIDEOCUBE can be any type of standard digital logic,(TTL,CMOS etc.) or any linear device. Thus it is possible to use your TV set as a monitor for your computer output, video camera or TV game. Available in partial kit (all hard to get parts), complete kit, and assembled.

STOCK NO:5499K	Completey assembled	$15.95	2/30.00
STOCK NO.5500K	Complete Kit	$11.95	2/22.00
STOCK NO.5500PK	Partial Kit	$9.95	2/18.00

PROGRAMMABLE TRANSFORMER. Originaly designed as an autotransformer, but by unsoldering a few terminals, becomes a transformer with 115 VAC in, and ELEVEN secondaries each 5 volts @ 10 Amps. Many voltage and current combinatins possible. Rated at 475 VA, so that almost all windings can be used at full output. We supply data showing the many combinations possible, such as 5 volts to 50 volts, in steps of 5 volts, all at 10 Amps. Plus much more.

STOCK NO.6544K PROGRAMMABLE TRANSFORMER $16.95   2/30.00

VISIT our 2 new retail outlets: DELTA ELECTRONIC HOBBIES, 5151 Buford Hwy. Doraville, (Atlanta) Ga. and DELTA ELECTRONICS, 590 Commonwealth Ave. Boston, Mass.

DELTA ELECTRONICS

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MINIMUM ORDER $5.00. Include sufficient postage, excess refunded. Send for new Catalog 18, bigger than ever.

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D13

INPUT/OUTPUT TERMINAL

A great place to start for building a microprocessor. These units were part of a comlex computer system. The terminal contains: keyboard; CRT; drive circuits; ASC11 output; and a complete 128 page technical manual with operating and repair instructions, which makes it easy to modify the terminal for your applications. (Character generator was part of a separate control section which is not supplied. The terminal can be used when modified using character generator LSI chips, such as the 2513, 2516 or other such IC's).

The keyboard is a 50 key alpha-numeric (and others) block keyboard, with ASC11 output. Display capactiy is 768 (12 lines of 64), 384, 256, 128 and so on, depending on character size desired. The character size may be adjusted from approximately typewriter size up to ¼".

The viewing screen of the CRT utilizes a high contrast, low persistence, emerald green phosphor. Each character is composed from a 5 x 7 dot pattern, registering clearly and sharply against a dark background. Controls provided include: on/off; brightness; focus; and character height.

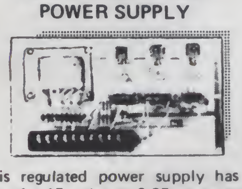
Great as a microprocessor input & output device. The display stations are used, removed from airline reservation systems, hotel reservation systems, stock exchanges, etc. Sh. Wt. 35 Lbs.

NEVER BEFORE at this LOW PRICE!
6NB60336 . . . . $34.50

DRINK MIXER KIT

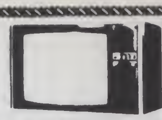
A real old-fashioned type like the kind at the local drug store back in the 1950's, except that these are brand new parts. Through a lucky purchase we have obtained some new parts of a drink mixer. It is complete but for the top cover, but you can make your own or operate without it. Evidently the manufacturer sold this line out to another and the tops got lost. Now you can build up a $20.00 mixer for under $5.00. Kids love 'em, order one today! Kit includes motor, mixer, screws, stand, line cord, switch, and 16 oz mixer cup. . . . . .Sh. Wt. 5 Lbs.
7M370053 . . . . $4.88
ALSO: Spare Mixer Cup for above,
Sh. Wt. 8 oz. . . 7M370054 . . $0.80 ea.

LOGIC AND OP AMP POWER SUPPLY



This regulated power supply has outputs of ±15 volts at 0.25 amps and +5 volts at 2.5 amps, with an input of 115 VAC. Manufactured by a computer company as part of a phone data terminal. Three (3) 723's (IC's) are used for voltage regulation. Units have barrier strip outputs, and are open ıme. Size: 5" x 9" x 2". New surplus. Qty. Ltd.
Sh. Wt. 5 Lbs . . . 6MI60215 . . . $17.50
3 for $45.00. . . 6MI60215 . . $45.00/3

COLOR T.V. CHASSIS



We have found some 2,000 TV chassis' that got damaged in a train derailment. These are the very same types of chassis' we have been selling: the TS-951 and the TS-953. We have sold over 2,000 of the perfect chassis and now we have a quantity that do not measure up to our high standards. They have cracked P.C. boards, bent frames, etc., but they are worth 3 times as much for the fantastic parts.

13" and 15" chassis' include tuners and controls. All chassis' sold "AS IS", all sales are final, no returns please.

13" Chassis . . 7DZ70059 . . .$22.50 ea.
Sh. Wt. 12 Lbs. ea. 10 for $198.00
15" Chassis . . 7DZ70060 . . .$22.50 ea.
Sh. Wt. 12 Lbs. ea. 10 for $198.00
17" Chassis . . . 7DZ70061 . . . .$14.88
Sh. Wt. 10 Lbs. ea. 10 for $128.88
19" Chassis . . . 7DZ70061 . . . .$14.88
Sh. Wt. 10 Lbs. ea. 10 for $128.50

CCTV COSMICAR "EE" T.V. LENSES

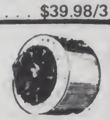
New surplus lenses made by Cosmicar for Mati. It's a super lens with fully automatic diaphram which opens by an electric eye control. These lenses maintain image luminance of 1001X against subject brightness EV from 11 to 17 (1500, 960001X) f/1.4, focal length = 25mm., fully automatic diaphram, EE acceptance angle = 30^{O}, EE response time is less than 4 seconds. "C" lens mount. List price was $300.00. Sh. Wt. 4 oz.
7VL70044 . . . SPECIAL! $150.00

REGULATED 10 to 24 Volt DC 2 Amp POWER SUPPLY KIT GREAT FOR C.B.

Here's an easy to build kit, designed to give maximum RF output to your CB. Can be built to deliver 13.8 volts DC regulated (2A) for mobile CB's, or switched over to give 10 to 24 volts DC (2A) regulated, to be used as a lab bench supply. Kit includes all parts and instructions to put together this versatile power supply, case not included.

Includes printed circuit board.
Sh. Wt. 10 Lbs . . . 6C60498 . . .$14.88
3 for 38.98. . . . 6C60498 . . . $39.98/3

0 to 24 VDC, 5 Amp POWER SUPPLY KIT



This power supply or battery charger kit should be useful to have around the house or shop. Easy to build, complete kit includes a 0 to 40 volt autotransformer (Variac^{r}), 24 volt 5 amp transformer, bridge rectifier, filter cap., and everything else you need to build this hefty power supply (case not supplied). Complete with instructions.
Sh. Wt. 12 Lbs . . . 6C60462 . . .$14.50
3 for $38.88. . . .6C60462. . . $38.88/3

POSTAGE: Please add sufficient funds for postage and insurance. Shipping weight for merchandise is listed at the end of each product description. All shipping is from Peabody, Ma. 01960.
Mass. Residents Add 5% Sales Tax.

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MODERN STANDARD TELEPHONES

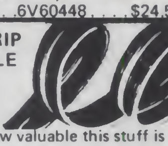
A complete, factory rebuilt, modern telephone ready for instant use. Available in black, white, beige, pink, red, green and blue. Ideal as an extra phone, for use on intercoms, private systems, extensions, etc. Easy 2-wire hook-up. Phones include hand set, induction coil, and cable, but no ringers. Many types and styles to choose from. When specifying a color, please give 3 choices in order of preference. Spec sheets with wiring diagrams are included, not detectable. Phones may vary slightly from photo. Sh. Wt. 8 Lbs.
(Call Director 10 line phone = 15 Lbs.)

† **Standard Desk Dial Phone**
Black, Desk Dial . . 6VL60440 . . $12.50
Color, Desk Dial . . 6VL60441 . . $17.50

† **Standard Wall Dial Phone**
Black, Wall Dial. . . 6VL60442. . . $12.50
Color, Wall Dial. . . 6VL60443. . . $17.50

† **2 Line Standard Desk Dial Phone**
This phone has a twist key to switch in 2 lines over the same phone, plus a hold position. Available only in black.
Black, 2-Line . . . 6V60448 . . . $24.50

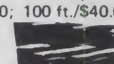
SPECTRA STRIP RIBBON CABLE



You all know how valuable this stuff is . . and now it's available at a fraction of list price. Several types available, order by "SS" or "ST" number, number of feet desired.

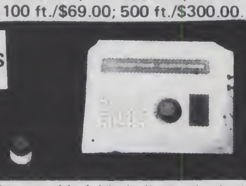
SS-1018: 10 conductor, 18 gauge. Prices: 3 ft./$1.00; 18 ft./$5.00; 40 ft./$10.00; 100 ft./$20.00.
SS-0822: 8 conductor, 22 gauge. Prices: 4 ft./$1.00; 20 ft./$5.00; 50 ft./$10.00; 100 ft./$17.00.
SS-1022: 10 conductor, 22 gauge. Prices: 6 ft./$1.00; 35 ft./$5.00; 80 ft./$10.00; 100 ft./$12.00; 200 ft./$22.00.
SS-1822-19BD-090: 18 conductors, 22 gauge, 19 strands, .090 thk. ground plane. Prices: 1 ft./$1.00; 6 ft./$5.00; 15 ft./ /$10.00; 50 ft./$25.00; 100 ft./$40.00.

SPECTRA TWIST RIBBON CABLE



ST-2422-7B: 24 conductors, 22 gauge, 7 strands per conductor. Prices: 3 ft./$1.25; 15 ft./$5.00; 35 ft./$10.00; 100 ft./ /$25.00; 500 ft./$100.00; 1,000 ft./ /$175.00.
3CT-5028-7B-05-125: Flat ribbon twist cable, used in place of shielded cable, reduces or eliminates cross-talk, 50 conductor, 28 gauge, 7 strands per cond. Prices: 1 ft./$1.25; 10 ft./$9.00; 50 ft./ /$40.00; 100 ft./$69.00; 500 ft./$300.00.

TV TENNIS GAME



1 or 2 players - Variable ball speed - dual paddle size - sound. These are questionable games returned to mfr. for one reason or another. He is too busy to repair, and needs mfg. room. His loss, your gain. Complete with schematic. Contains 20 74LS series chips, other chips, power supply & other stuff. 115VAC operation. Designed by MIT.
Sh. Wt. 4 Lbs. . . 7ZU70161 . . . $10.00
4 for $38.88. . 7ZU70160 . $38.88 for 4

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$10.00 Minimum on Charge Orders

CARD CAGE WITH GUIDES AND CONNECTORS

This cage has 37 PC board edge connectors for 1/16" thick cards. Connectors are wire wrap type with double edge contacts, 0.125" spacing. The card rack has 18 rows of 2 types of connectors: 30 contact and 85 contact types. Over-all dimensions: 18"L x 11"W x 10"H. Removed from used equipment, this was once part of a data display terminal.
Sh. Wt. 13 Lbs . . . .5U00210. . . .$9.50
3 for$25.00 . . . 5U00210 . . . $25.00/3

MICROPROCESSOR MAIN FRAME

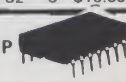
Through a lucky purchase we have obtained a quantity of the main frames from the Viatron System 21 Computer. These contain the 5U00210 card cage mentioned above, plus five UG-90 connectors, male and female power supply connectors, display terminal base, etc. Looks ideal for building a microprocessor in. Possibilities unlimited!
Sh. Wt. 25 Lbs . . 6BAE60129 . . $19.50
3 for $49.50. . . 6BAE60129 . . . $49.50

TRANSFORMERS

We have over a million transformers in stock! The list below includes some of our most popular transformers for use in power supplies. This is only part of our vast selection. All primaries are 115 VAC.

Sh. Wt.	Order No.	Volts	Amps	Price
6	5H00013	18	5	
		17	5	$8.50 ea
		10	8	
10	4EX245	24	5	$4.00 ea
10	X045 *	27(ct)	5	$7.00 ea
10	6H60528	15	15	$8.00 ea
15	6H60529	24(ct)	5	
		24 or		
*Ferro-Resonant type.		32	3	$10.00 ea

TOUCH-TONE GENERATOR CHIP ME 8900



New surplus tone generator chip: this one chip will generate dual frequency tones for a 2 in 8 code as used in all touch-tone phones. This chip can be interfaced into any telephone system. Operating voltage of 4.5 to 35 volts; no crystal required for freq. gen.; exceeds CCITT reommendations; data transmission capability. Chip is shipped complete with IC socket, a four page data sheet and a data package showing unique applications. Qty. Ltd.
Sh. Wt. 8 oz. . . . 7VL70160 . . . .$6.95
10 for $60.00. . 7VL70160 . .$60.00/10

CHARACTER GENERATORS MOS - ROM

The Mostek 6095 character generator
Features: 64 dot matrix (5x7) characters with column by column output; High speed character access time and column select access time; Completely static operation, no clocks required.
Applications: CRT alpha-numeric display; LED array driver; billboard and stock market displays.
Each **ROM** contains 2,240 bits of programmable storage, organized as 64 characters, each having 5 columns of 7 bits. Complete data sheet included.
Sh. Wt. 8 oz . . . . 7IC70020 . . . .$10.00
(Specify Mostek 6095 ROM & order no.)

FUNCTION GENERATOR CHIP INTEL 8038

New surplus from a local manufacturer who needed cash fast. You save!
Sh. Wt. 8 oz. . . . .7IC70167 . . . .$4.75
3 for $12.75. . . 7IC70167. . . $12.75/3
(Specify Intel 8038 with part number.)

B&F ENTERPRISES
119 FOSTER STREET
PEABODY, MASS. 01960
(617) 531-5774 / 532-2323

B&F

B4

computer display terminal

This display terminal has an integral controller B/W cathode ray rube and keyboard. The system has a serial I/O interface for communication and I/O interface for a printer.

External logic & power pack not shown.

DISPLAY (P/N 4802-1095-501) FEATURES:
- 17" B/W CRT
- 41 lines of data
- 52 characters per line
- Characters are generated by a diode matrix "graphic" technique
- 21 special push-buttons wired for a program call up
- Brightness Control
- Self-contained power supply

KEYBOARD (P/N 4802-1115-501) FEATURES:
- Reed switch technology
- 54 data keys
- 28 special keys detachable with cable

LOGIC UNIT (P/N 4802-1157-502) FEATURES:
- 1024 by 6 bit core memory
- Printer I/O interface
- Communication I/O interface

POWER: 115V, 50/60 Hz, 500 Watts

WEIGHT: 210 lbs. (including logic unit, keyboard, display and cables.)

$ 180.00

4 way cursor control, graphics display.

The story: These are unused terminals made for airport ticketing & seat assignment. After several years of storage they require tinkering to make operable. We have some hints printed such as cleaning PC fingers. One of our customers has this tied into his KIM-1, another has his running with his IMSAI. We have data on this. Should be useable on most common computers. A hell of a deal and all for a paltry $180.00. Don't be left out as many were on our past VIATRON deal. Sold "as is" all sales final.

FOB LYNN MASS (you pay shipping)
Check with order please.

WITH COMPLETE DOCUMENTATION

SPECTRA FLAT TWIST

50 conductor, 28 gauge, 7 strands/conductor made by Spectra. Two conductors are paired & twisted and the flat ribbon made up of 25 pairs to give total of 50 conductor. May be peeled off in pairs if desired. Made twisted to cut down on "cross talk." Ideal for sandwiching PC boards allowing flexibility and working on both sides of the boards. Cost originally $13.00/ft

SP-324-A $1.00/ft. 10 ft/$9.00

SP-234-A $1.00 ft 50 cond. 10 ft/$9.00
SP-234-B .90 ft 32 cond. 10 ft/$8.00

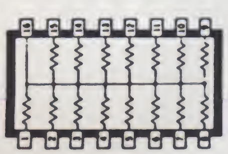
WIRE WRAP WIRE

TEFZEL blue #30 Reg. price $13.28/100 ft. Our price 100 ft $2.00; 500 ft $7.50.

MULTI COLORED SPECTRA WIRE

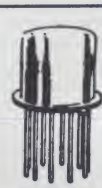
Footage		10'	50'	100'
8 Cond.	#24	$2.50	9.00	15.00
12 "	22	3.00	11.00	18.00
14 "	22	3.50	13.00	21.00
29 "	22	7.50	28.00	45.00

Great savings as these are about 1/4 book prices. All fresh & new.



Precision 16 pin DIP network as shown. Each resistor 1K. For pull-up/pull-down interface networks. Value over $1.00 each; New, CTS or Beckman

SP-320 pack of 6 $1.00



TINY SWITCH TELEDYNE

In tall TO-5 can
DPDT, 24 volts. Brand new.
cost $16.00 each
SP-134 $3.00 each 2/$5.00

Meshna

Please add shipping cost on above. Minimum order $10

FREE CATALOG SP-9 NOW READY

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M-2

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WORLD'S ONLY COMPLETE RETAIL CENTER FOR MINI- AND MICROCOMPUTERS, PERIPHERALS, SUPPLIES, SOFTWARE AND SERVICE!

Now featuring the entire Data General Micro-NOVA line. Factory-assembled and tested at the component, board and system levels. Full software; full support; full service; and **off-the-shelf delivery!**

PRICE LIST

The Computer Store carries the complete Data General micro-NOVA computer line, available for off-the-shelf delivery.
All units, components, and systems are fully factory assembled and tested on the component, board, and system levels. May 1, 1977 — prices subject to change.

MAINFRAMES

8561 micro-NOVA computer with 4K words (8K bytes) of RAM and nine-slot chassis. Price includes operator panel, key-lock switch, power supplies, rack mounts, and I/O bus terminator $1,995

8560 micro-NOVA computer with 4K words (8K bytes) of RAM and eighteen-slot chassis $2,595

MEMORY

8572 4K words (8K bytes) MOS RAM board-960ns cycle time .... $ 600

8573 8K words (16K bytes) MOS RAM board-960ns cycle time .... $ 950

8568 1K words (2K bytes) PROM .... $ 375

8569 2K words (4K bytes) PROM .... $ 500

DISKETTE SYSTEMS

6038 One-drive Diskette system with 315K bytes. Includes integral data channel controller. NOVA 3 compatible diskette $2,900

6039 Two-drive Diskette System $3,900

SINGLE BOARD COMPUTER

8563 Micro-NOVA microcomputer with 4K words MOS RAM on a single 7½" x 9½" board. Includes onboard timing and buffering circuitry for memory expansion to a full 32K words, and I/O expansion for multiple high-performance devices .... $ 950

CRT DISPLAYS

6052 Alphanumeric video (CRT) display terminal with detachable keyboard. Switch selectable speed (10 steps, 110 to 19.6K baud) parity (even/odd/mark), and mode (line/local). Standard EIA or 20ma interface, 11 key data entry pad, 8 function keys, 64 character set (ASCII upper case). 24 line x 80 character screen with 5 x 7 dot matrix characters. Complete with 25-foot signal cable $1,990

Alphanumeric video (CRT) display terminal with detachable keyboard. Switch selectable speed (10 steps, 110 to 19.6K baud) parity (even/odd/mark), and mode (line/local). Standard EIA or 20ma interface, 11 key data entry pad, 11 function keys, 96 character set, direct cursor positioning and sensing, programmable intensity plus blank and underscore, and 24 line x 80 character screen with 5 x 8 dot matrix characters. Complete with 25-foot signal cable $2,290

Software distribution and documentation charges apply to all qualifying DOS systems. The one-time documentation and distribution charge applies to all other microNOVA systems that are licensed for DOS.

MISCELLANEOUS

1098A Carton of 10 diskettes, performatted and verified .... $ 120

4210 General Purpose I/O card, accommodates 14-40 pin packages .... $ 250

4211 Wire-wrap pins and sockets for 4210 .... $ 200

1114 Pre-drilled circuit cards — predrilled and etched for up to 50, 14-pin dual in-line packages ...... $ 200

2303A Extender Card .... $ 200

1115A Card Puller Tool .... $ 50

8574 PROM Programmer (Burner) Board, Mounts in computer frame. Has female board connector for installation of Model 8567 through 8570 PROM boards. PROMS are programmed and tested word-by-word under program control. Model 8574 includes six (6) 825126 (1024-bit) and six (6) 825130 (2048-bit) chips $1,650

continued...

highlighting

E & L INSTRUMENTS

MMD-I MINI-MICRO DESIGNER

EDUCATION AND DEVELOPMENT MICROCOMPUTER

- COMPLETE 8080A MICROPROCESSOR-BASED COMPUTER SUITABLE FOR EDUCATION AS WELL AS SOFTWARE AND SYSTEM DEVELOPMENT
- SIMPLE ENOUGH FOR SELF-INSTRUCTION AND YET COMPLETE ENOUGH FOR THE PROFESSIONAL SYSTEMS DESIGNER AND CLASSROOM TEACHING
- BASIC SYSTEM CONTAINS COMPLETE 8080A MPU SET INCLUDING MEMORIES WITH ADD-ON MEMORY AVAILABLE
- DIRECT KEYBOARD ENTRY OF DATA AND INSTRUCTIONS (NO DATA ENTRY TERMINAL NECESSARY)
- LIGHT EMITTING DIODE STATUS AND DATA INDICATORS
- INTEGRAL SOLDERLESS BREAD-BOARDING SOCKET WITH DIRECT BUFFERED ACCESS TO THE MICROPRO-CESSOR
- COMPLETE SELF CONTAINED POWER SUPPLY
- COMPLETE TUTORIAL DOCUMENTATION AND OPERATING MANUALS
- PROVISION FOR DIRECT TELEPRINTER OR CRT TERMINAL AND AUDIO CASSETTE INTERFACES

tCS # 561 KIT . . . .$422.50 tCS # 563 Assembled $595.00

Product of the Month

NEW, INTEL MEMORY BOARDS FOR THE S-100 COMPUTERS . . .
ALTAIR/IMSAI and others

Special

The Computer Store is now accepting orders for the new INTEL memories for S-100 computers. The units are fully assembled and factory tested. The memories are 9 bits (parity!) and each includes one spare "hot" chip (tested and ready to use).

16K Memory Board . . . $485
32K Memory Board . . . $845

MICRO NOVA *Price List, continued. . . .*

8576A Replacement 1024-bit PROM chips

4207 Asynchronous Interface Board. Single-line interface board for asynchronous terminals. Transmit and receive speeds (110 baud plus 150, 300, 600, 1200, 2400, 4800, or 9600 baud), EIA or 20-mA current loop operation . . . . $ 250

4009 Teletype Mod Kit. Converts Models 33ASR TZ, TC, TU or TER to on-line operation for use with 4207 microNOVA and 4207 . . . . $ 200

4208 Console Debug Option. Mounts on Asynchronous Interface Board and allows any ASCII console to

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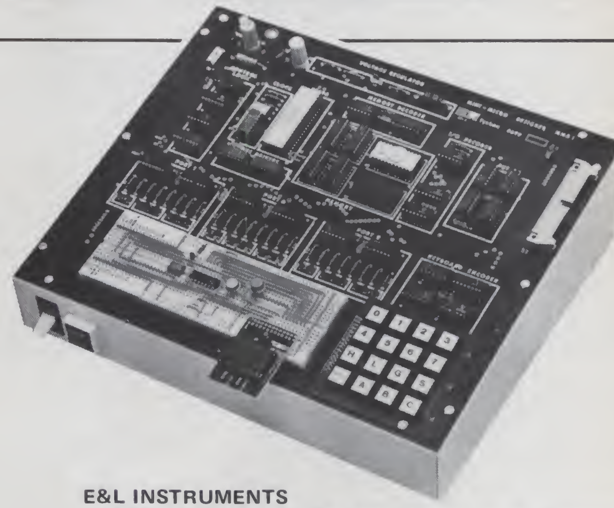
COMPUTERS-



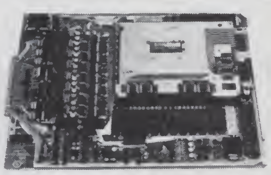
DATA GENERAL
MicroNOVA, single-board with 2K, 16-bit words . . . $800
MicroNOVA System, 4K 16-bit words, nine-slot chassis, operator front panel w/keylock, power supply, I/O terminator . . . $1995

NEC
NEC, EVA-kit
Assembled, tested 8800 system on a board with documentation. Was: $398.00 — NOW: $159.00

MITS/ALTAIR
The Computer Store stocks the full line of MITS/Altair equipment.
SPECIAL:
For ham interface, the MITS SIOB board, Kit . . . $124

E&L INSTRUMENTS
MMD-1, Mini-micro Designer, Development Computer Kit . . . $422.50 Assembled . . . $595.00
Complete 8080A with power supply and breadboard. All tutorial documentation and operating manuals.

MEMORIES-



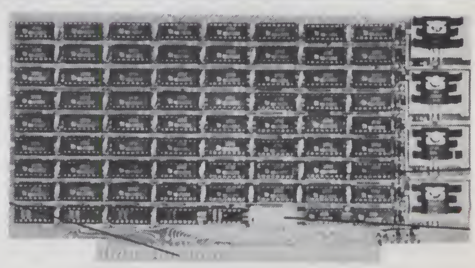
ADD-ON MEMORIES/STANDARD MEMORIES Off-the-shelf

PDP-II
HII BUSCOMM 16K Increments . . . $3217 each
Full UNIBUS compatibility — no power from host — faster (750 ns) . . . $3179 w/o parity
RII — BUSCOMM 32K Increments . . . $4372 each. UNIBUS compatible, 750 ns.

INTERDATA — PINCOMM I 16K Increments . . .$2034
Plug compatible w/INTERDATA 7/16, 7/32, 8/32, 50, 55, 70 and 74. 750 ns.

GENERAL AUTOMATION — PINCOMM A
8K Increments . . . $1417 each. 16K Increments . . . $1983 each.
Form, fit, function memory for 6A SPC-16, Models 40, 45, 60, 65 and $85.

STANDARD MEMORIES — Santa Ana, CA



FOR ALTAIR, IMSAI USERS
SEALS, 8K Memories. Kit . . . $296
SPECIAL: Limited supply, 16K, Static memories, fully assembled and tested, S100 compatible. Ass'd . . . $650

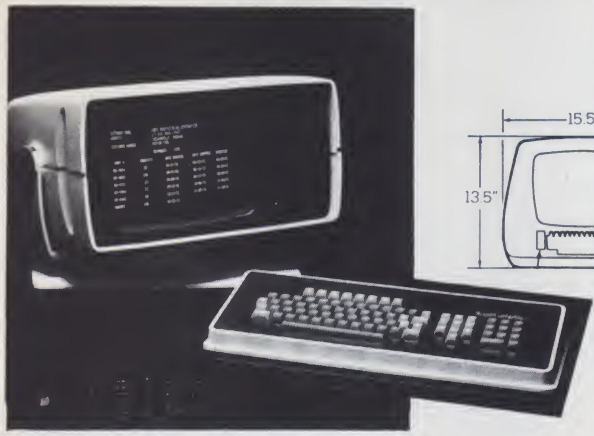
DATA GENERAL
8K 16 bit-words (16K bytes), 960 ns MOS RAM . . . $950
2K 16 bit-words (4K bytes), PROM . . . $500

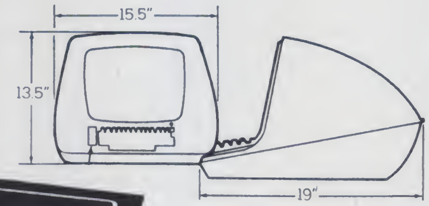
Price List, continued...
supervise program execution as well as examine and/or modify RAM locations and CPU registers. Includes Automatic Program Load routine . . . $ 200

OTHER OPTIONS (S.O.)
8565 Automatic Program Load. Provides for a switch-initiated program load from a character-oriented device controller. Device code and type specified by jumpers on CPU board . . . . $ 150
8564 Handheld Programmer's Console. Calculator-format programmer's console interfaced to computer via a single-card interface, and a 10-foot 16-line flatribbon cable . . . . $ 700

continued...

CRT TERMINALS





DATA GENERAL
6053 Alphanumeric Display Terminal with detachable keyboard. Ass'd . . . $2290

LEAR SIEGLER
ADM-3A Assembled . . . $1245,
Kit . . . $845.00

COMPUCOLOR 8001 SYSTEM
8080 CPU, ROM BASIC, 8K RAM, Keyboard, full color. Ass'd . . . $2995

PRINTERS-

DATA GENERAL
DASHER, 60 cps, 132 columns, typewriter keyboard, U/L case with EIA or 20 mA interface. Ass'd. . .$2400

CENTRONICS
Model 700 60cps, 132 column, 13-19 lpm. Ass'd . . . $1520
Model 701 60cps bi-directional, 132 column, 26-120 lpm. Ass'd . . . $1815

DIGITAL EQUIPMENT DECwriter II/LA-36DE, U/L case, 30 cps, 132 columns. Ass'd . . . $1990

☆ NEW PRODUCT!!! IMMEDIATE DELIVERY

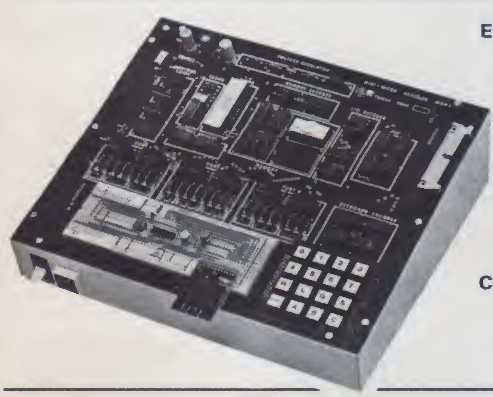
SCI Systems, Series 1100
Rotary Printer . . . $1245

The revolutionary SCI printer has a speed of 2200 characters/sec, 40, 80, 132 characters/line, 24 line format with full ASCII 64 character set in a 4" x 5" x9" package.

The printer is factory assembled and tested and comes with an enclosure and standard RS232-C interface.

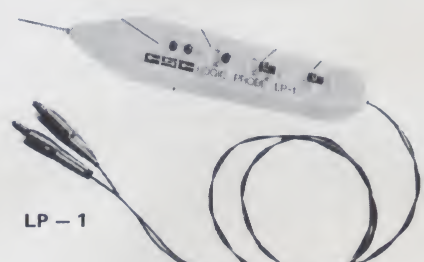
The SCI printer can copy a full 1920 character screen in less than one second.

DESIGNER EQUIPMENT-



E&L INSTRUMENTS
OA3, OP-AMP Designer. Kit . . . $102.50. Ass'd . . . $155.00
BB4, Universal Powered Breadboard. Kit . . . $135.00. Ass'd . . . $94.50
DD1, Digital Designer. Kit . . . $77.75. Ass'd . . . $127.75
For all digital circuit work, includes clock, power supply, logic lights, pulsers, switches and more.

CONTINENTAL SPECIALITIES
LM-1, Logic Monitor . . . $74.95 (Ass'd)
Design Mate 4, Pulse Generator . . . $124.95 (Ass'd)



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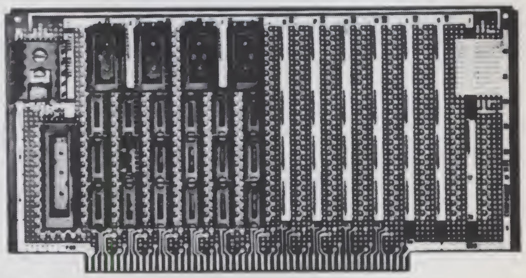
ASSEMBLY TOOLS & AIDS-

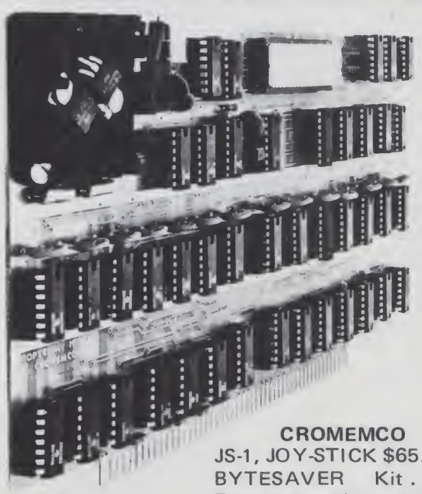
OK MACHINES
- SP-50, Solder-Sucker . . . $11.30
- BW-630, Hobby-Wrap, Battery powered wire-wrap gun . . . $34.95
- 3907, Wire-Stripping tool . . . $7.25

WELLER SP23K, 25 Watt Soldering Iron set, recommended for computer kits . . . $8.95

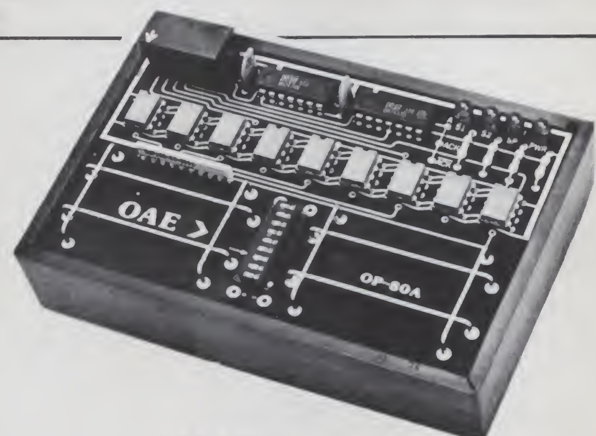


VECTOR
- 8800 VDP, Altair/Imsai prototype board . . . $19.95
- R32, Socket Pins, Gold, Package of 100 . . . $14.95
- Wiring Pencil . . . $9.50
- Slit 'n Wrap . . . $75.00

MICROCOMPUTER PERIPHERALS-



CROMEMCO
- JS-1, JOY-STICK $65.00 (Kit)
- BYTESAVER Kit . . . $195.00 Ass'd . . . $295.00
- Fast Analog I/O with 7 channels
  Kit . . . $145.00 Ass'd . . . $245.00



OLIVER AUDIO
- OP-80A, Manual Paper tape reader . . . $74.50 (Kit)

CONTROLS RESEARCH Keyboard Kit . . . $75.00

SUPERSCOPE C-103, Audio Tape Recorder . . . $89.95

COMPONENTS All new, JUNE SPECIALS
- 2708 . . . $25.00/each
- 1702A . . . $6.50/each
- Altair/Imsai 100 pin connectors . . . $7.95
- Altair card guides . . . $1.95/pair
- Cannon plug set, 25 pin (Male, female, cover) . . . $11.00

SUPPLIES
TTY PAPER
Yellow $4.00/roll, White $5.50/roll, TTY Ribbons: $2.75/ each

Paper Tape
Grey, oiled; Fan-fold: $6.00/ box, $2.50 / Roll

INFORMATION TERMINALS
Floppy Disks, FD-32-1000, Altair/Pertec compatible: $8.75

3M
- Data Cartridge, DC300A, IBM compatible . . . $20.00 ea.
- Data Cartridge, DC100A, mini-cartridge . . . $16.00/ea

Price List, continued...

8566	Battery Backup. Provides power to maintain valid data contents in MOS memories during power failure for up to 30 minutes . . . . $ 300

microNOVA DOCUMENTATION

3649 (SO)	microNOVA Paper Tape Diagnostics including listing. Tests processor and exercises memory and I/O devices . . . . $ 150
3650 (SO)	microNOVA Diagnostic Operating System (DTOS). Diskette-based diagnostics that test processor, memory, and I/O devices. Includes listings and DTOS manual . . . . $ 100
3570	microNOVA Computer - Programmer's Reference Manual. Includes detailed discussion of internal structure of microNOVA, instruction set, interrupt processing, and I/O programming . . . . $ 10
3568	microNOVA Computer Systems Technical Reference. Provides specifications for microNOVA boards, peripherals, chassis, power supplies, and packaged systems. Contains operating characteristics and I/O programming of microNOVA peripherals . . . . $ 10

continued...

BOOKS-

1977 I/C MASTER CATALOG ... $29.95

TEXAS INSTRUMENTS
Transistor & Diode Data Book . . . $4.95
TTL Data Book . . . $4.95
Linear and Interface Circuits Data Book . . . $6.95

ADAM OSBORNE
Introduction to Micro Computers. Vol. I . . . $7.50. Vol. II . . . $12.50

CONTROL DATA INSTITUTE
Kapur . . . IBM 360 Assembler . . . $15.95
Shellyl . . . Introduction to Flowcharting . . . $6.95
Shellyl . . . Introduction to RPG . . . $9.95
Kapur . . . Programming in Standard COBOL . . . $10.50
Rulel . . . FORTRAN IV Programming . . . $8.50

MARTIN RESEARCH
Microcomputer Design . . . $25.00

OTHER
Henry F. Legard . . . Programming Proverbs . . . $6.50
David Ahl, 101 BASIC Games . . . $7.50
Ted Nelson, Computer Lib/Dream Machines . . . $7.00
Donald E. Knuth . . . $7.00
The Art of Computer Programming
Volume I, Fundamental Algorithms . . . $20.95
Volume II, Seminumerical Algorithms . . . $20.95
Volume III, Sorting & Searching . . . $20.95

Price List, continued...

3569 (SO) microNOVA Integrated Circuits-Technical Reference. Provides specification for Data General-manufactured microNOVA integrated circuits. Includes information on mN603, mN606, and all buffer devices . . . $ 15

3651 microNOVA Software Manuals — includes Diskette Operating System (DOS) User's Manual, Fortran IV User's Manual, and Real-Time Operating System RTOS User's Manual . . . . $ 45

COMPUTER PACKAGES OF DOCUMENTATION

Computer Packages of Documentation include schematics, diagnostic tape and listings, wire lists, technical manuals, microNOVA Tech Reference Manuals, and Illustrated Parts Lists.

TRAINING

M101 "Designing with the microNOVA." Includes training on all hardware and software microNOVA products as well as interfacing information. One-week course (on-site training available) . . . . $ 375

microNOVA CHIP SET KITS (SO)

8563A microNOVA CPU/4K Chip Set Kit. Engineering evaluation assembly kit for construction of a Model 8563 microcomputer assembly. Includes full systems documentation . . . . $ 900

4210 microNOVA General Purpose Interface Chip Set Kit. Engineering evaluation assembly kit for construction of a Model 4210 Interface Card. Includes full systems documentation . . . . $ 200

The Computer Store accepts both Master Charge and BankAmericard.
____Charge Master Charge ____Charge BankAmericard

Sign your name Amount of order
Print name exactly as it is on your card
Good thru Inter Bank number
Enter above the exact number on your card
Your billing address
City State Zip
(Charge customers fill in above)

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NAME first name middle initial last name
Rural Route **Rural Box No.** **P.O. Box No.**
Company
Street address
City **State** **Zip**
Date

HOW MANY	CATALOG NUMBER	NAME OF ITEM	PRICE		TOTAL PRICE Dollars	Cents
	SHIP VIA:	(Specify) See other side for shipping information				

Payment Method: MO CCK MC COL CSH BAC PO (for store use only)

TOTAL FOR GOODS		
TAX (See Note)		
TOTAL CASH PRICE		
AMOUNT ENCLOSED		

NOTE: If you live in Mass., add 5%.

C.O.D. ORDERS must be accompanied by 20% Deposit. Delivering carrier will require cash or certified check in payment of C.O.D. amount. No C.O.D. for FPO, APO or countries outside USA.

C.O.D. Fees (in Addition to Postage)

We can ship via Air Parcel Post, Parcel Post Special Handling or Special Delivery, Air Express, Bus or Air Freight, if you so request. Contact your local office for rates and delivery information.

Prices subject to change without notice.

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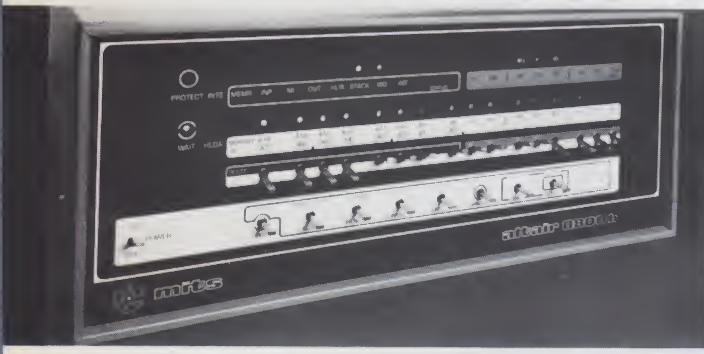

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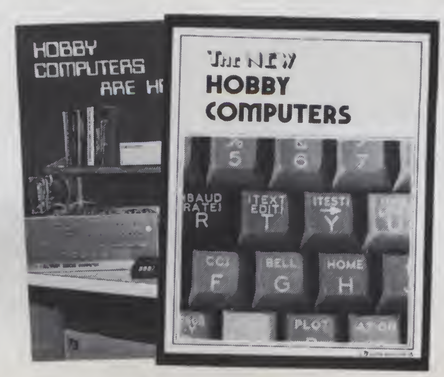

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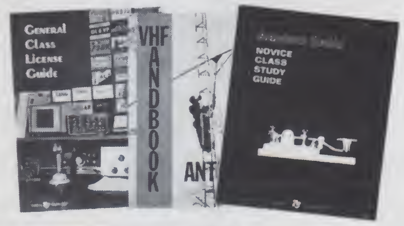

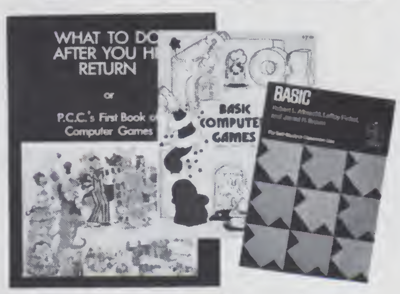

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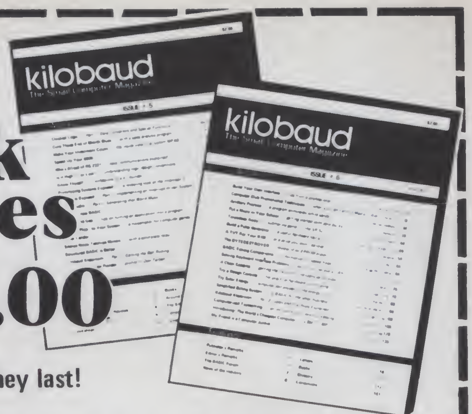

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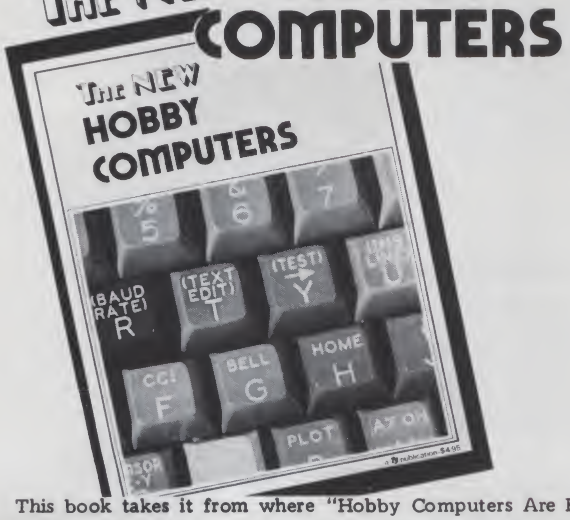

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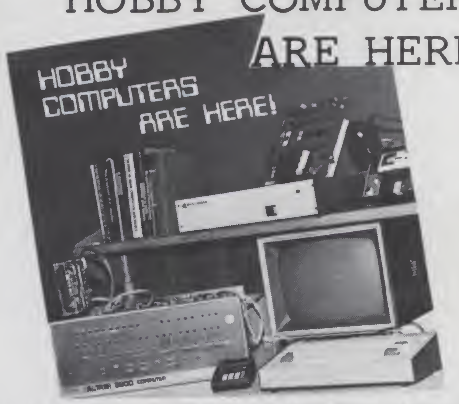

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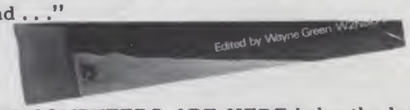

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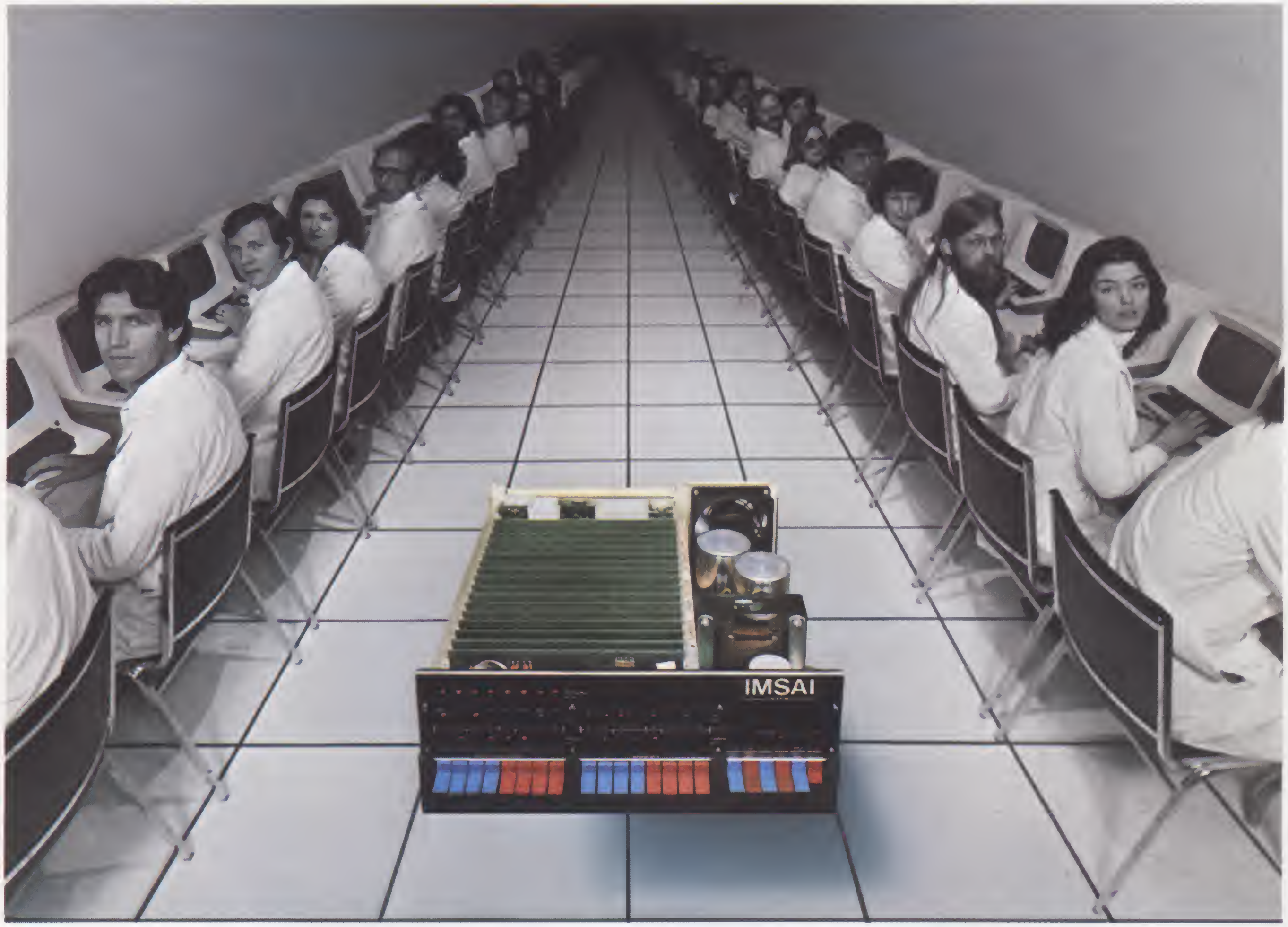

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